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ABSTRACT

Reported are the origins, development, and preliminary evaluation of a self-instructional training system to prepare deaf high school students for entry-level electronic assembly jobs in industry. Description of the training system focuses on the following topics: the instructional concept on which the system is based; the method of instruction (including samples from programed texts and filmstrips); the seven learning objectives (such as mechanical assembly and component installation); and administrative characteristics (such as length of the curriculum and teacher requirements). In a section on development of the training system, antecedents of the project (such as a World War II training program) are discussed, and a chronology of project development is provided. Preliminary evaluation involving developmental testing and on-site tryout of prototype materials with approximately 85 hearing impaired students is said to have yielded findings that the program results in achievement of the specified learning objectives, allows for adaptation to individual differences, stimulates peer-tutor relationships, can be highly motivating, requires full-time administration by teachers, and is based on a valid instructional model. (LS)

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ED 112 600

ELECTRONIC ASSEMBLY

SELF-INSTRUCTIONAL TRAINING SYSTEM FOR THE DEAF:

DOCUMENTARY REPORT

Prepared by

Leo E. Persselin, Ph.D.
Project Director

December 31, 1970

Contract No. OEC-0-8-001920-3321(019)

Media Services and Captioned Films
U.S. Department of Health, Education, and Welfare

TRW
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One Space Park
Redondo Beach, California

EC 073 850

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ELECTRONIC ASSEMBLY

SELF-INSTRUCTIONAL TRAINING SYSTEM FOR THE DEAF:

DOCUMENTARY REPORT

I. PURPOSE OF THE REPORT

The purpose of this report is to document the origins and development of the Electronic Assembly Self-Instructional Training System for the Deaf. The content and functions of the system are described, together with the instructional concept on which the system is based. Both the conceptual and developmental antecedents of the system are identified. An evaluation of instructional and administrative effectiveness is based on tryout and classroom experience.

II. SUMMARY

The objective of system development was to provide a self-instructional curriculum which would prepare deaf high school students for entry-level electronic assembly jobs in industry. A second objective was to base system development on a model of instruction which could serve for the development and improvement of other curriculum, both vocational and academic.

A course of instruction was devised consisting of seven discrete units, each encompassing progressively more complex aspects of the electronic assembler's job. The titles of these units are: 1) Mechanical Assembly; 2) Wire Preparation; 3) Assembly Soldering; 4) Wire Installation; 5) Wire Harness Building and Installation; 6) Component Installation; and 7) Electronic Assembly Rework Techniques. In the process of completing these units, the trainee acquires the knowledge and performance skills necessary for assemblying electronic chassis and printed circuit boards, and learns to work independently from industrial assembly drawings and wiring diagrams.

The trainee receives individual instruction at a workbench equipped with electronic assembly tools, parts, and materials, and a 35mm filmstrip projector and screen for individual viewing.

Instruction is presented in the form of coordinated programmed textbook and filmstrip materials. The trainee learns at his own pace, responding to instruction by entering written answers into his textbook, and by performing electronic assembly tasks at the workbench.

The system does not eliminate the need for a classroom teacher. Guided by a programmed manual, the teacher periodically monitors and evaluates the trainee's work, administers achievement tests upon completion of each of the seven instructional units, and refers the trainee to remedial instruction as necessary.

The concept for the system derived from a World War II audiovisual training program, successful production-aid applications of learner-centered audiovisual instruction in industry, and research in programmed learning effectiveness for the deaf and mentally retarded.

Project development was proposed in 1966 and began in 1967. By the end of 1969, a prototype version of the entire system had been completed and had undergone tryout at the Oregon School for the Deaf, Salem, and the California Schools for the Deaf, Berkeley and Riverside.

After revision of instructional materials based on tryout results, a classroom version was produced for demonstration and evaluation in schools for the deaf and rehabilitation settings. During the fall semester 1970, this version was introduced into the curriculum at the California Schools for the Deaf, Berkeley and Riverside; American School for the Deaf, West Hartford, Connecticut; and the Salem Rehabilitation Center, Oregon. Eight workbenches were installed at American School for the Deaf; six at the California School for the Deaf, Berkeley; and five each at the California School for the Deaf, Riverside, and the Salem Rehabilitation Facility.

At the Salem Rehabilitation Facility, the system is being demonstrated and evaluated for use with other handicapped populations in addition to the deaf.

Experience in administering instruction to approximately 85 trainees indicates that the system is both instructionally effective and economical: a workbench can be installed, complete with electronic assembly gear and filmstrip projector and screen for $1,000 or less. The cost of expendables for each trainee can be less than $35.

Deaf trainees of normal intelligence, but with reading grade levels as low as 3.5, have successfully completed the course of instruction and met the specified performance objectives. Average time for completing instruction is approximately 100 hours, with individual completion times ranging from 50 hours or less to 200 hours or more.

Length of individual instructional periods appears to be an important variable in instructional effectiveness. Both the speed and quality of the trainees' work has tended to increase with longer instructional periods. No problems exist in holding the trainees' interest and keeping them at their workbenches during the longer periods.

The system appears to be both flexible and adaptive to individual learning styles. One consistent characteristic of administration in multiple-workbench classrooms has been the spontaneous emergence of peer-tutor relationships between trainees.

Because programmed learning materials bear the burden of communication and instruction, the classroom instructor need not be an experienced teacher of the deaf. In fact, experience to date indicates that the best instructor is an experienced electronic assembler, assembly supervisor, or electronic technician. A competent instructor can supervise the work of 10 trainees, each at an individual workbench.

The system is clearly applicable to other populations than the deaf. The self-pacing feature makes it highly attractive for mixed groups with individual learning differences. Because it does not require a high level of reading skill, and because of its self-motivating aspects, the system may well serve a broad range of handicapped and retarded learners in both school and rehabilitation settings.

III. DESCRIPTION OF THE TRAINING SYSTEM

A. Objective of the Training System

The objective of the Electronic Assembly Self-Instructional Training System for the Deaf is to provide the trainee with specific skills which will permit him to compete successfully for an entry-level job as an electronic assembler in industry.

The curriculum encompasses seven skill areas, each one representing a progressively more complex aspect of electronic assembly work:

1. Mechanical Assembly
2. Wire Preparation
3. Assembly Soldering
4. Wire Installation
5. Wire Harness Building
6. Component Installation
7. Electronic Assembly Rework Techniques

The trainee learns to read and independently work from industrial assembly drawings and wiring instructions and acquires the skills necessary for making electronic assemblies. In the process of completing the course of instruction, the trainee actually puts together a mechanical assembly, assembles an electronic terminal-board chassis, builds and installs a wire harness, and installs components on a printed circuit board.

No theory is taught. The skills and procedures learned are only those typically required on the job, as defined by detailed task analyses in industrial settings. Thus, while the trainee learns to operate voltage regulators for use with soldering irons and thermal wire strippers, the words "volt" and "voltage" are never used.

The training system was designed to provide terminal vocational instruction for both boys and girls during the senior year in high schools for the deaf. The system was designed for learners of normal intelligence and a reading level no lower than the 3.5 grade level.

B. Instructional Concept

Exhibit 1 shows the basic model of tutorial instruction which was the point of departure in designing the training system. As depicted in this model, the learner receives an increment of instruction; he responds to the instruction, the response is evaluated; the learner receives immediate feedback as to the quality of the response; and selection and presentation of the next increment of instruction is made on the basis of the preceding evaluation.

To the extent that the lesson presentation, evaluation, and feedback functions can be automated, it is possible to achieve automated, programmed instruction. Completely self-instructional programmed learning is achieved when these functions are automated to the extent that a learner may independently meet all learning objectives without requiring the presence of an instructor. Within this context, the complexity of completely "automated" programmed learning might range from simple text programs to highly complicated computer-based audiovisual systems.

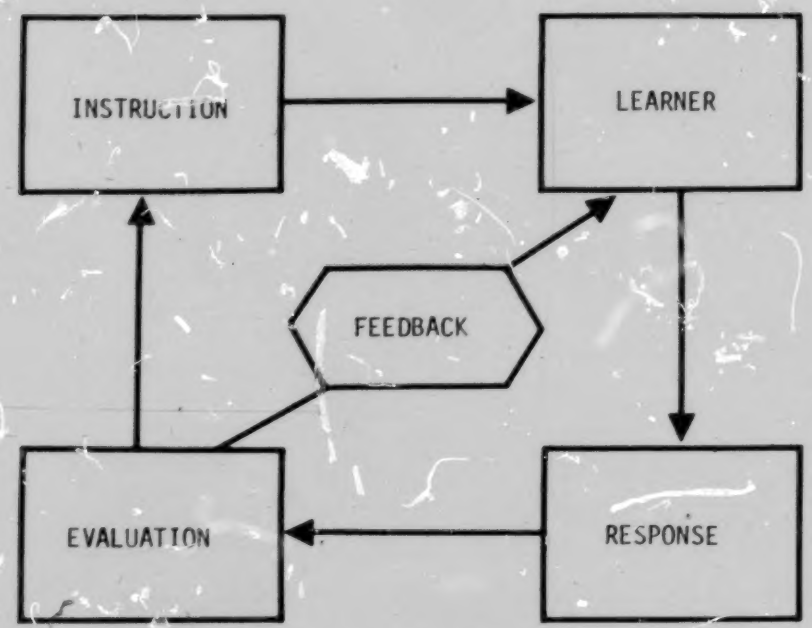


Exhibit 1. Conceptual Model: Tutorial Instruction.

Exhibit 2 shows the adaptation of the basic tutorial model which was actually used. In this model, the classroom instructor is not eliminated from the system, but rather is programmed into it.

As depicted, instruction revolves around a program of self-instruction through which the trainee proceeds individually and at his own pace. The trainee responds to instruction through programmed learning exercises. Self-tests permit the trainee to evaluate his own work, acquire immediate feedback, and select subsequent increments of instruction.

The role of the teacher is to monitor the trainee's work and the trainee's evaluation of that work, to reinforce learning by confirmation of achievement, and to provide supplementary and remedial instruction as required. The teacher's involvement is programmed just as the trainee's activities are programmed.

In this model, the burden of instruction is borne by the individualized programmed learning. The teacher's role essentially is that of quality assurance. It is patterned after the job of the quality assurance inspector in an industrial setting. The teacher's primary function is to assure that the standard of performance set by the program is achieved and maintained, and to be sure the learner is aware of and corrects any deficiencies in his work.

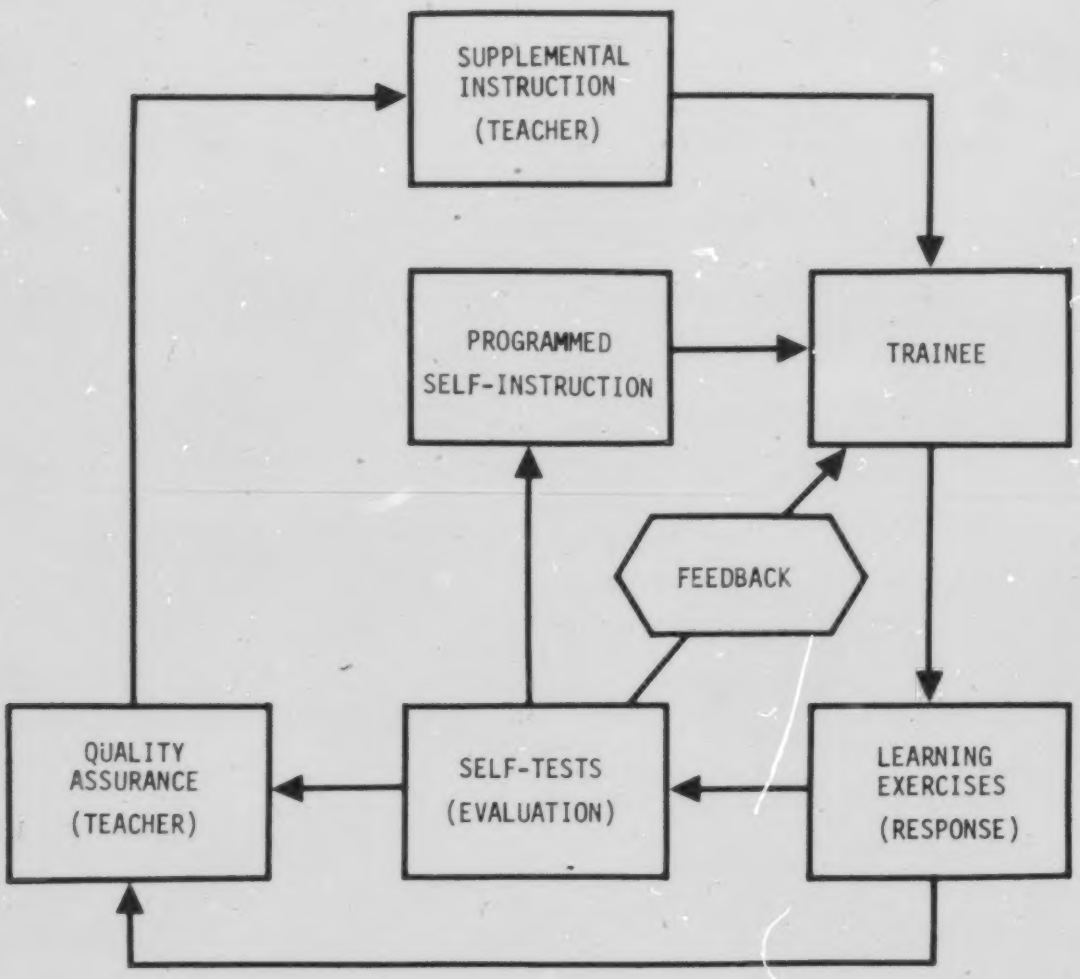


Exhibit 2. Conceptual Model: Electronic Assembly Self-Instructional Training System for the Deaf.

C. Method of Instruction

Each of the seven skill areas covered by the curriculum is represented by a discrete unit of instruction. The titles of these units are:

1. Mechanical Assembly
2. Wire Preparation
3. Assembly Soldering
4. Wire Installation
5. Wire Harness Building and Installation
6. Component Installation
7. Rework Techniques

Instructional materials for each unit consist of the following:

1. A programmed textbook and coordinated color filmstrips.
2. Coordinated assembly drawings and wiring instructions.
3. A final examination.
4. A teacher's manual.

The trainee receives individualized instruction at a workbench completely equipped with all required electronic assembly tools, parts, and materials. The workbench also incorporates a 35mm filmstrip projector and a table-top screen for individual viewing. Except for the projector and screen, the workbench and its furnishings are representative of those found in most industrial settings.

The trainee learns at his own pace. He controls the filmstrip presentation and responds to step-by-step text and filmstrip instruction by entering written answers into the programmed textbook or by performing electronic assembly tasks. Learning exercises approximate on-the-job activities as closely as possible.

Normally, the teacher interacts with the trainee only when he is called for. The programmed textbook periodically instructs the trainee to ask the teacher to check his work. In addition, the trainee may call on the teacher whenever he feels he needs help.

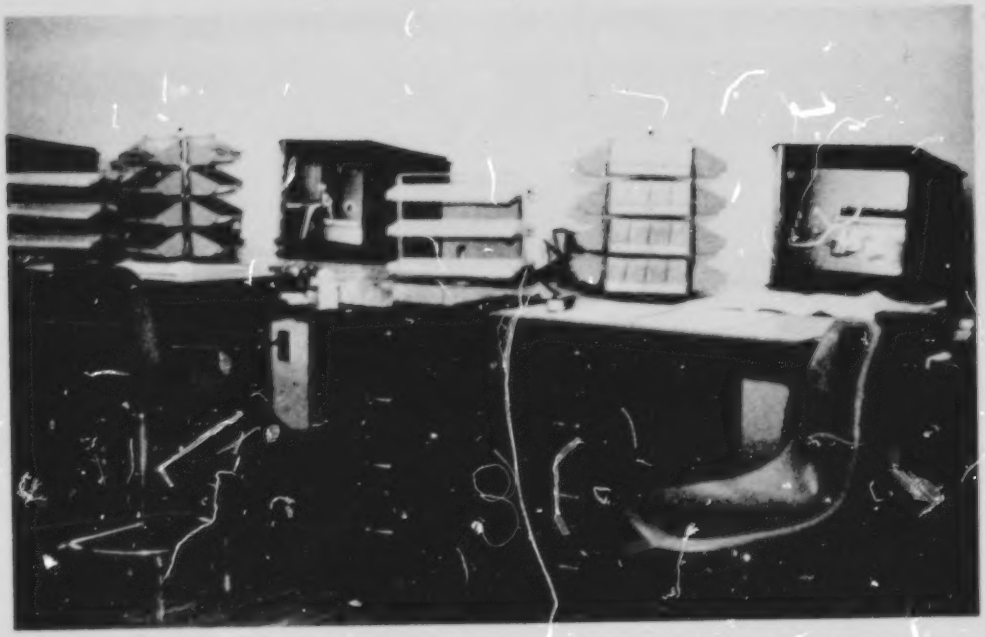
The teacher checks and evaluates the trainee's work with the aid of data in the teacher's manual. If remedial instruction is required, the teacher may refer the trainee to appropriate programmed learning material or may provide supplemental instruction in person. The teacher also administers the final examination for each unit. The examination is designed to assure that the trainee has achieved all primary learning objectives, and to reveal any learning deficiencies which must be corrected before the trainee goes on to the next unit.

Exhibit 3 shows different types of workbench and classroom arrangements. At American School for the Deaf, West Hartford, Connecticut, eight workbenches are installed against opposite walls of the classroom. At California School for the Deaf, Berkeley, six workbenches are installed back-to-back.

In Exhibit 4, the top picture shows an electronic assembly on the workbench, one of those which the trainee actually builds during the course of instruction. The trainee's programmed textbook is on the right. An assembly drawing is on the left. The numbered and lettered bins in both the top and bottom pictures contain electronic assembly hardware. The numbers and letters correspond to data in the programmed textbooks and assembly drawings.

The bottom picture in Exhibit 4 shows a slide projector, rather than a filmstrip projector, because California School for the Deaf, Riverside, is equipped for slides rather than filmstrips. The types of workbenches and workbench accessories shown in Exhibits 3 and 4 may differ, but the basic arrangement of each workbench is the same.

One of the design objectives of the training system was that all electronic assembly and filmstrip projection hardware should be on-the-shelf and readily available from retail dealers. This objective was met. No special equipment of any kind was created for the system. Different types of workbenches and workbench accessories may be used, as long as they meet functional specifications.



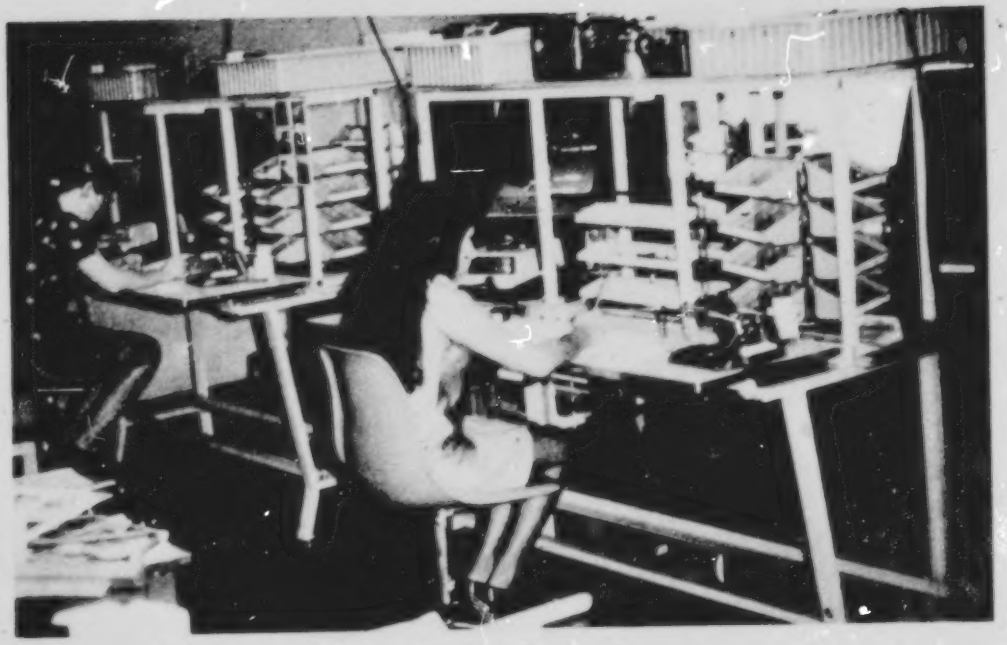


Exhibit 3. Electronic Assembly Classrooms. Top: American School for the Deaf, West Hartford, Connecticut. Bottom: California School for the Deaf, Berkeley.

Exhibit 3. (Continued) Top: California School for the Deaf, Riverside.
Bottom: California School for the Deaf, Berkeley.

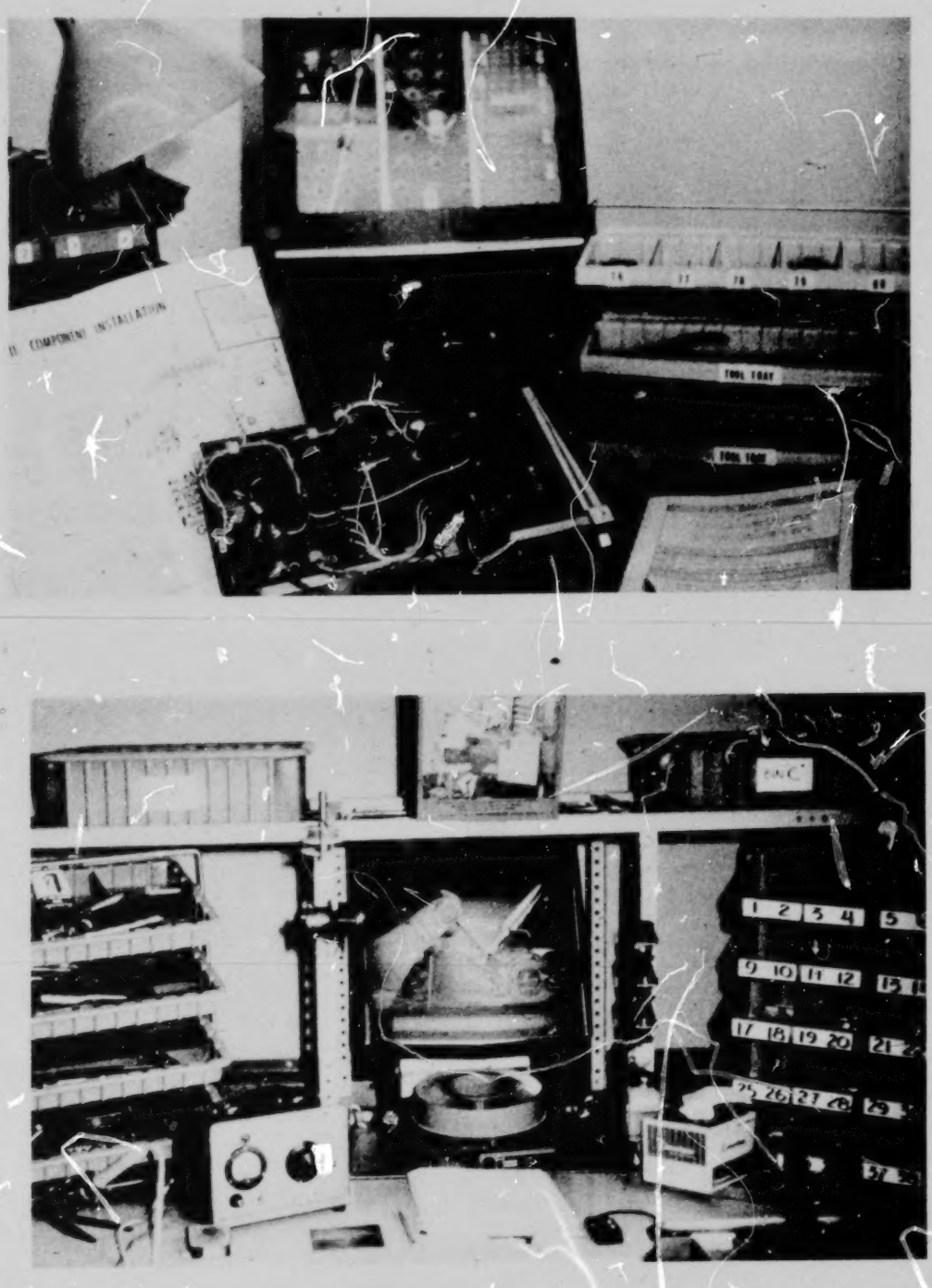


Exhibit 4. Electronic Assembly Workbenches. Top: American School for the Deaf, West Hartford, Connecticut. Bottom: California School for the Deaf, Riverside.

Exhibit 5 shows a sample page from one of the programmed textbooks. Every frame (step) of instruction in the textbook is accompanied by a numbered frame on the filmstrip. The filmstrip frames accompanying the sample page are reproduced in Exhibit 6.

In the sequence of instruction shown in Exhibits 5 and 6, Frame 44 provides the trainee with textbook instruction only. After writing his response to the question in Frame 44, the student will proceed to filmstrip Frame 44-Answer for the correct answer to the question. Throughout all seven instructional programs (units), all question frames are in the form of filmstrip and/or text. All answer frames are filmstrip only.

Frame 45 is an information frame consisting of both filmstrip and text. Note that both Frames 44 and 45 refer the trainee to something he already has learned. The trainee is asked to transfer that knowledge (i.e., component leads are wrapped and stress relief is made the same as in wire installation). No terminology is taught throughout the sequence because all terminology already has been learned.

Frame 46 requires a performance response. "Bin 72" in Step 1 refers to one of the numbered bins shown in Exhibit 4.

Frame 47 is a criterion frame which permits the trainee to evaluate his own work. Prior to reaching this point in the instructional program, except for stress relief, the trainee already has learned all of the other criteria in Frame 47.

Frame 47 also calls for a teacher's check. Exhibit 7 shows the teacher's checklist for Frame 47. The teacher's manual contains a similar checklist for every "Teacher's Check" frame in all seven programs.

44. You will wrap component leads to terminals the same as you wrapped wire.

How will you wrap component leads?

_____ A. Wrap both leads at the same time.

_____ B. Wrap one lead at a time.

44-ANSWER

45. When you install a component, you must make a stress relief in the leads, the same as you made in bare wire.

The picture shows a stress relief.

46. Read each step, and then do it:

1) Get a component from Bin 72. Center the component between two terminals.

2) Begin the wrap by twisting the lead around one terminal.

3) Finish the wrap.

Wrap one lead to a terminal now.

47. Inspect your wrap:

A. Is the component centered? _____

B. Is the color code on the left? _____

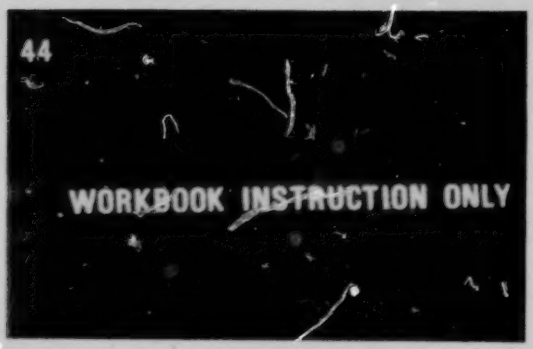
C. Is there a good stress relief? _____

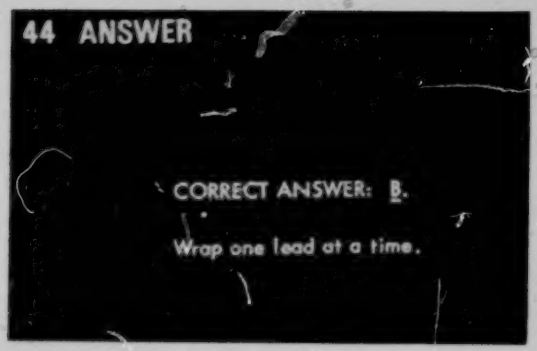
D. Is the wrap tight? _____

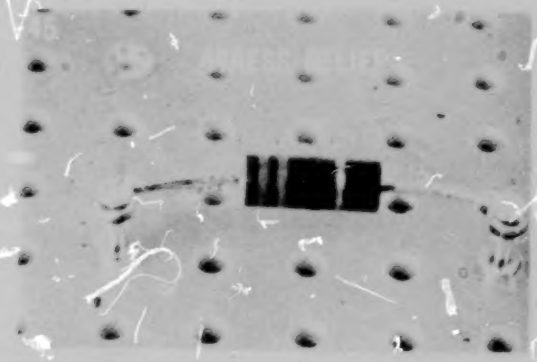
After you make a correct wrap, ask your teacher to check your work.

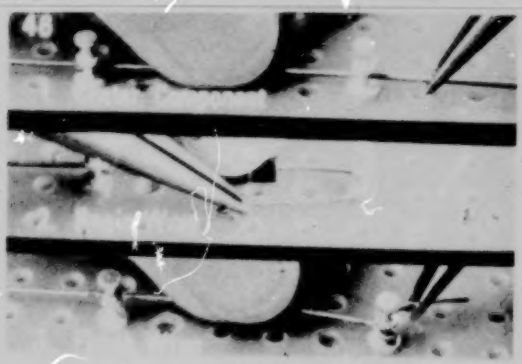
Teacher's Check: _____

Exhibit 5. Programmed Textbook (Excerpt): Component Installation.









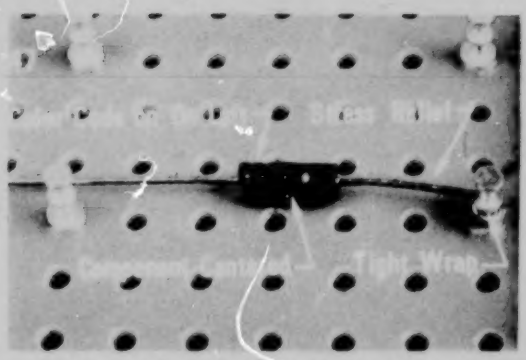


Exhibit 6. Filmstrip Frames: Component Installation.

Instructor's Check List

COMPONENT INSTALLATION

Electronic Assembly Program No. 6

Frame	Activity	Check List
47	Connecting Components To Turret Terminals Stress Relief	1) Component centered. 2) Color code on left. 3) Leads wrapped to bottom of terminals. 4) Leads wrapped in same direction. 5) Full wraps --- tight wraps. 6) No kinks or nicks in leads. 7) FRAME 48: Good stress relief. 8) FRAME 62: All leads trimmed. Component body flat against board. Good 90° bends in leads.
62	Connecting Components To Turret Terminals Component Body Flat Against Terminal Board	

Exhibit 7. Teacher's Checklist (Excerpt): Component Installation.

Exhibit 8 shows another sample page from one of the programmed textbooks.

In this sequence, Frame 85 calls for a performance response based on both text and filmstrip content.

Frame 86 provides text instruction only, but requires a written response based on data which the trainee must seek and find in an assembly drawing. Exhibit 9 shows the data in excerpts from the assembly drawing.

Frame 87 provides both text and filmstrip instruction, but once again the trainee must refer to the assembly drawing to correctly execute the performance response. Frame 86 has assured that the trainee knows how to interpret the assembly drawing (Step 20).

Frame 88 provides text instruction only, with a performance response again based on data in the assembly drawing. Exhibit 10 shows the teacher's checklist for Frame 88.

In addition to providing the criteria for evaluating the trainee's work, the teacher's checklists also serve as references for prescribing remedial instruction. The "Activity" lists in the teacher's checklists conform to the outline of learning objectives (see page 30, Learning Objectives) for all seven instructional programs. If a trainee's performance is in any way deficient, a quick scanning of the "Activity" list for appropriate instructional content will immediately reveal what learning exercises are required to correct the deficiency.

All programmed learning content throughout the entire sequence of seven programs is linear. No branching instruction is provided. Repetition of self-instructional exercises, with whatever personal help might be needed from the teacher, is the basic strategy for remediation.

In addition to the teacher's checks, another diagnostic instrument is the final examination which follows completion of each of the seven instructional programs. Each examination is designed to confirm that the trainee has achieved specified learning objectives,

85. Your multi-conductor cable has insulating material between the inner conductors. This material looks like rope.

Cut off the material between the inner conductors. The picture shows how.

Cut off the material now.

86. Step 20 in the Assembly Drawing shows how long to cut the inner conductors.

How long does Step 20 show to cut the inner conductors?

A. The red wire (R) must be _____ inches long.

B. The black wire (BK) must be _____ inches long.

C. The green wire (GN) must be _____ inches long.

D. The white wire (WH) must be _____ inches long.

86-ANSWER

87. Cut the inner conductors for Step 20.

The picture shows how to measure each conductor.

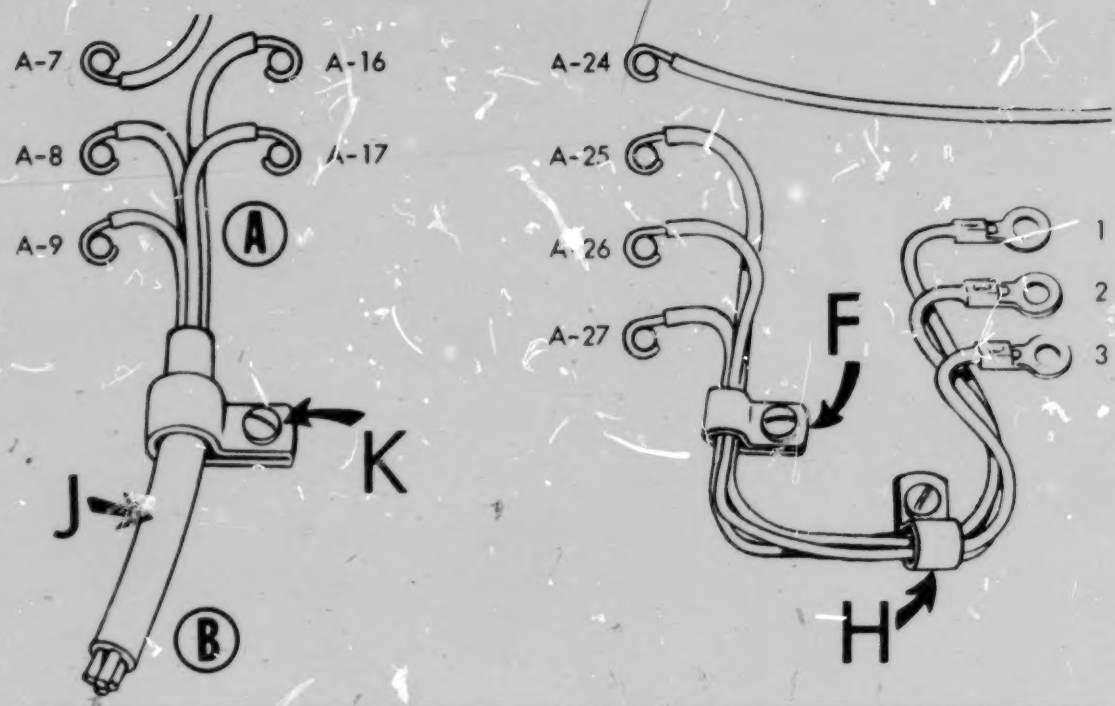
Measure and cut the inner conductors now.

88. Do Step 21 in the Assembly Drawing now.

After you finish, ask your teacher to check your work.

Teacher's Check: _____

Exhibit 8. Programmed Textbook (Excerpt): Wire Installation.



ASSEMBLY INSTRUCTIONS		
✓	STEP NO.	INSTRUCTIONS
	1	AWG # 20 BARE WIRE A-1/A-10(NS)
	2	AWG # 20 BARE WIRE A-2/A-11(NS)
		SOLDER -10 AND A-2 1
		AWG IRE A- A-6(
	17	20 . RE A O NC NECT G-
	18	8" AWG # 20 INSULATED WIRE A-27/G-3(S) DO NOT CONNECT G-3
	19	DRESS WIRES A-25, A-26, A-27 FLAT TO CHASSIS INSTALL CLAMPS F AND H (BIN 46)
	20	PREPARE END Ⓐ OF CABLE J: CUT "0" OF MULTI-CONDUCTOR CABLE. STRIP END Ⓐ 2-3/4". CUT INNER CONDUCTORS TO LENGTH: R, 1-1/2"; BK, 2"; GN, 2-3/4"; WH, 2"
	21	PREPARE END Ⓑ OF CABLE J: STRIP END Ⓑ 3". CUT INNER CONDUCTORS TO LENGTH: R, 3"; BK, 2-1/2"; GN, 2"; WH, 1-1/2"

Exhibit 9. Assembly Drawing (Excerpt): Wire Installation.

WIRE INSTALLATION Instructor's Check List Page 4

Frame	Activity	Check List
88	Preparing Multi-Conductor Cable Assembly Steps 20 and 21 Cable J	1) Cable 10 inches long. 2) Outer insulation stripped: End A --- 2-3/4"; End B --- 3". 3) Good strips. 4) Protective materials neatly removed. 5) Inner conductors cut to length: End A --- R-1-1/2", BK-2", GN-2-3/4", WH-2" End B --- R-3", BK-2-1/2", GN-2", WH-1-1/2"
90	Installing Multi-Conductor Cable Assembly Steps 22 and 23 Cable J - End A: GN/A-16(NS) BK/A-17(NS) WH/A-8 (S) R/A-9 (S) Install Clamp K	1) Correct end of cable installed. 2) Wires connected to correct terminals. 3) Terminals wrapped from correct direction. 4) 180° wraps. 5) Good service loops. 6) Good insulation clearance. 7) No damage to insulation. 8) Good solder joints --- A-8, A-9. 9) Clean connections.

Exhibit 10. Teacher's Checklist (Excerpt): Wire Installation.

and to reveal any deficiencies which must be corrected before the trainee goes on to the next unit of instruction. Examination questions are presented in the form of text materials only. No filmstrip materials are used in any of the examinations.

Exhibit 11 shows the entire final examination for Mechanical Assembly, the introductory program of the series. A primary objective of this examination is to assure that the trainee has adequate reading and comprehension skills for continuing with the programs which follow. Thus, six of the eight questions require a written response. These questions emphasize the correct identification of tools, fasteners, and parts, as well as the ability to describe their use. Three questions require the student to demonstrate tool-handling and assembly skills he has learned. To complete the final question, the student must make the assembly shown in the assembly drawing.

Throughout all seven programs, a consistent procedure is used for instructing terminology and nomenclature. A new tool, part, fastener, or piece of equipment is introduced only at the point that the trainee is required to use it. The item is identified by name in both the programmed textbook and filmstrip, and the trainee sees a picture of it on the filmstrip frame. The trainee is instructed to get the item immediately, and he has it in his hands while he learns its name, the names of its parts, what it is used for, how it operates, etc. The trainee is taught to use the item in assembly procedures as rapidly as possible.

The learning of nomenclature and terminology is achieved primarily through written responses, and is reinforced through use of the language in technical instructions. This is true for all seven instructional programs. As indicated by the final examination for the Mechanical Assembly program (Exhibit 11), final examinations for the first two programs emphasize language learning requirements by calling for a large number of written responses.

FINAL EXAMINATION

MECHANICAL ASSEMBLY

Electronic Assembly Program No. 1

1. Write the name of the fastener in each bin:

   A. Bin 1 _____

   B. Bin 2 _____

   C. Bin 4 _____

   D. Bin 5 _____

   E. Bin 6 _____

   F. Bin 9 _____

   G. Bin 10 _____

   H. Bin 22 _____

2. When you install a cable through a hole in a metal chassis, you must keep the cable from being cut by the sharp edge of the hole.

   What part can you install to keep the cable from being cut?

   _____

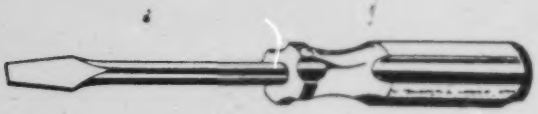
3. Write the name of the tool you must use to fasten the screws in each bin:

   A. Bin 4 _____

   B. Bin 5 _____

Exhibit 11. Final Examination: Mechanical Assembly.

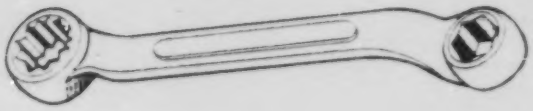
4. Write the name of each tool:



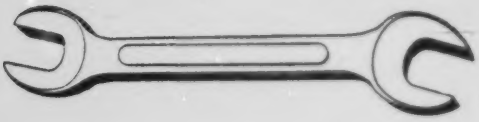
A _____

B _____

C _____

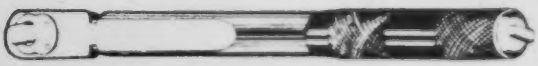


D _____



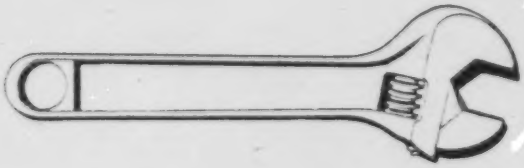
E _____

F _____



G _____

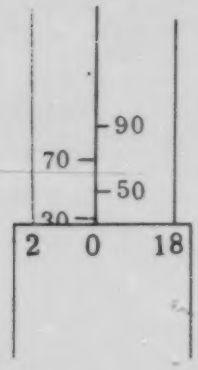
H _____



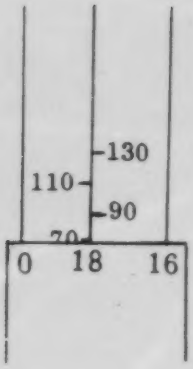
I _____

Exhibit 11. (Continued)

5. What is the setting on each torque wrench?



A. _____ in/lbs.



B. _____ in/lbs.

6. Why must you use a torque wrench on some connections?

_____

7. Read each step, then do it:

   1) Get the torque driver from your tool tray.

   2) Set the scale at 14 in/lbs.

   3) Lock the torque driver.

   After you finish, ask your teacher to check your work.

8. Make the assembly shown in Assembly Drawing 2-A.

   Before you begin, ask your teacher to watch you work.

Exhibit 11. (Continued)

2-A

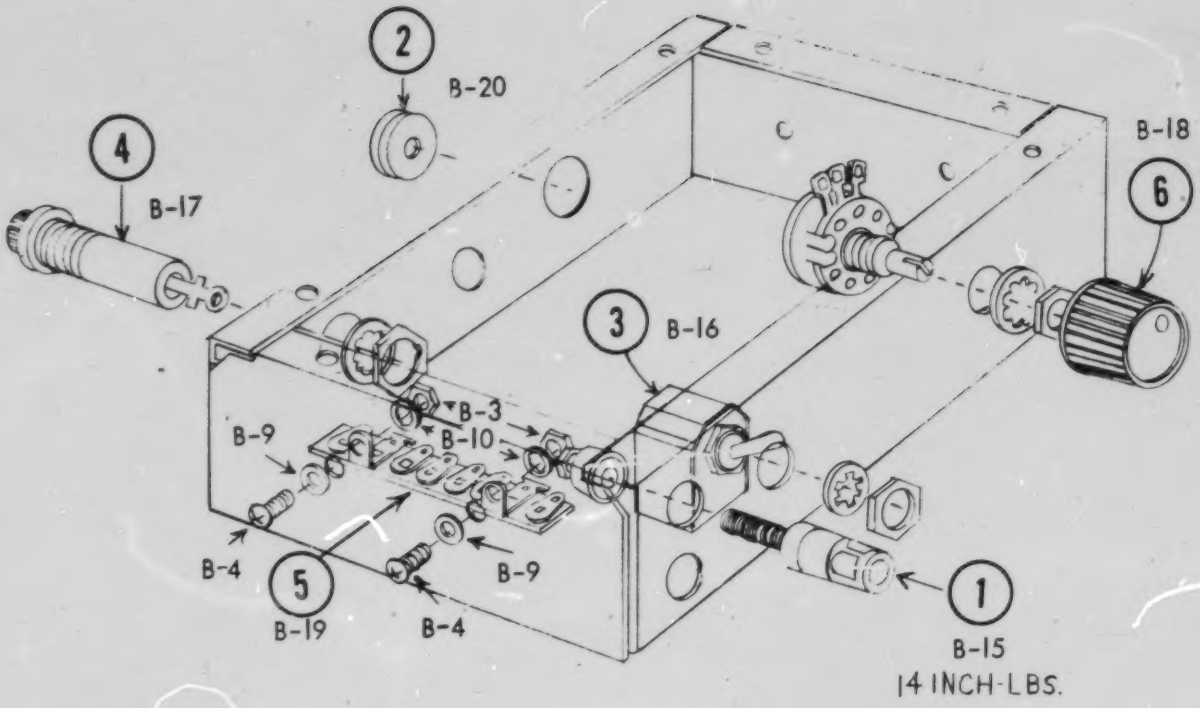


Exhibit 11. (Continued)

Beginning with the final examination for the third program in the series, emphasis shifts to the performance of assembly skills rather than written responses. If the trainee can follow the technical instructions and do the work called for in performance of assembly tasks, there is no longer any question as to his achievement in learning nomenclature and terminology.

Exhibit 12 shows the final examination for Component Installation, the next-to-the-last of the seven programs in the series. The entire examination is on a single page. No written responses are called for. In order to complete this examination, the trainee must 1), assemble a terminal board chassis, and 2) and 3), demonstrate two different techniques for installing components in a printed circuit board. The assembly drawing and assembly instructions at the top of the examination page are the only reference materials available to the trainee for making the turret terminal assembly.

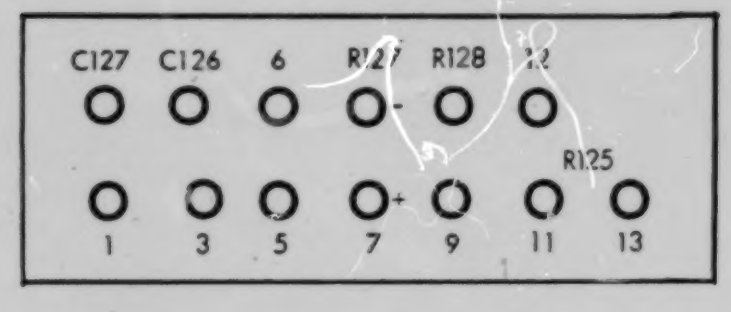
The teacher's manual contains checklists for each final examination which are similar to the checklists for the programmed textbook/filmstrip activities. Exhibit 13 shows one page of the teacher's checklist for the Component Installation examination. This is the checklist for Step No. 3 of Question 1.

In addition to the checklists for both the programmed textbook/filmstrip activities and the final examinations, the teacher's manual also contains special assembly drawings which the teacher may use for preparing work samples, together with inventories for stocking and replenishing electronic supplies at the workbenches.

FINAL EXAMINATION

COMPONENT INSTALLATION

Electronic Assembly Program No. 6



1. Do all of the Steps in the Assembly Instructions:

ASSEMBLY INSTRUCTIONS			
✓	STEP NO.	BIN NO.	INSTRUCTIONS
	1	74	1/2 WATT 22Ω RESISTOR 1/C127 (NS)
	2	75	.01 MFD 100V TUBULAR CAPACITOR 3/C126 (NS)
	3	72	1/2 WATT 150,000Ω RESISTOR 5/C126 (S)
	4	72	1/2 WATT 150,000Ω RESISTOR 9/R128 (NS) USE THIS KIND OF STRESS RELIEF:
	5	75	.01 MFD 100V TUBULAR CAPACITOR 11/13/R125 (NS)
	6	76	20 UF 30V ELECTROLYTIC CAPACITOR (+)7/(-)R127 (NS)
	7	77	.01P LKV DISC CAPACITOR 1/C127 (S)

2. Get a 1/2-watt 22mΩ resistor from Bin 74. Install it in any two holes on your printed circuit board. Clinch the leads. Solder the connection.

3. Get a 1/2-watt 22mΩ resistor from Bin 74. Install it in any two holes on your printed circuit board. Do not clinch the leads. Solder the connection.

Exhibit 12. Final Examination: Component Installation.

Item 1 (continued)

Step 3

_____ 1. Resistor connecting 5/C126 (NS).

_____ 2. Leads straightened and cleaned.

_____ 3. Terminals cleaned.

_____ 4. Leads connected to bottom of terminals.

_____ 5. Lead at terminal 5 wrapped in same direction as connections 1 and 3.

_____ 6. Lead at C126 wrapped in opposite direction from first lead.

_____ 7. Lead at C126 not wrapped around lead of capacitor.

_____ 8. Component centered.

_____ 9. Color code at top.

_____ 10. Good stress relief.

_____ 11. Wraps tight and trimmed.

_____ 12. Good solder connections.

_____ 13. No damage to leads or terminals.

_____ 14. Cleaned connections.

Exhibit 13. Examination Checklist (Excerpt): Component Installation.

D. Learning Objectives

1. Mechanical Assembly

In the introductory program of the series, the trainee learns to make assemblies with mechanical fasteners --- nuts, screws, bolts, etc. The trainee learns the names and correct uses of a dozen different tools and a dozen different mechanical fasteners and parts. He learns to read and work from mechanical assembly drawings.

One of the drawings used in the program is shown in Exhibit 15. In the process of completing the program, the trainee puts together the assembly depicted in the drawing. The assembly is shown in Exhibit 14.

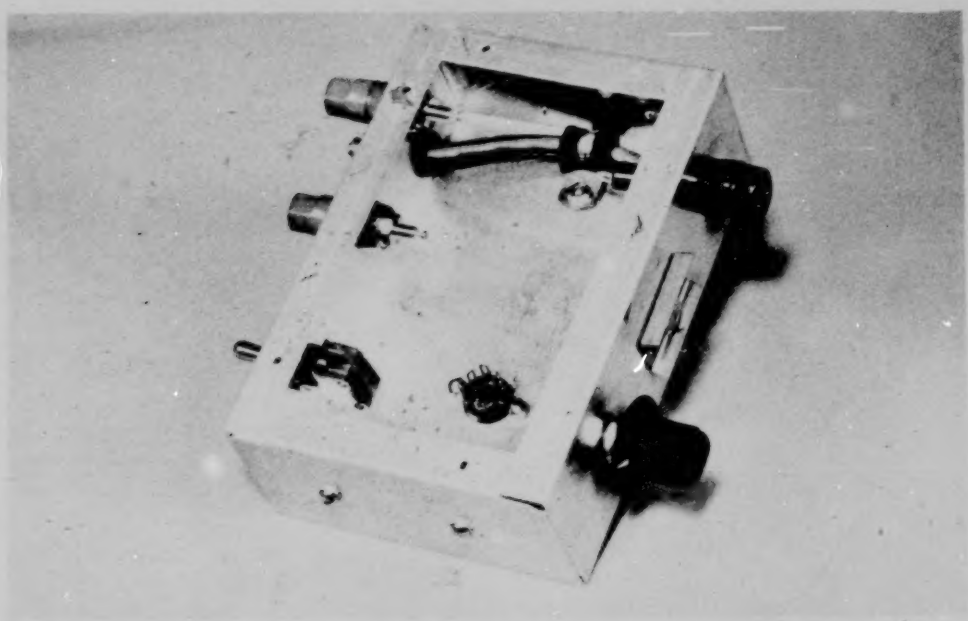


Exhibit 14. Mechanical Assembly.

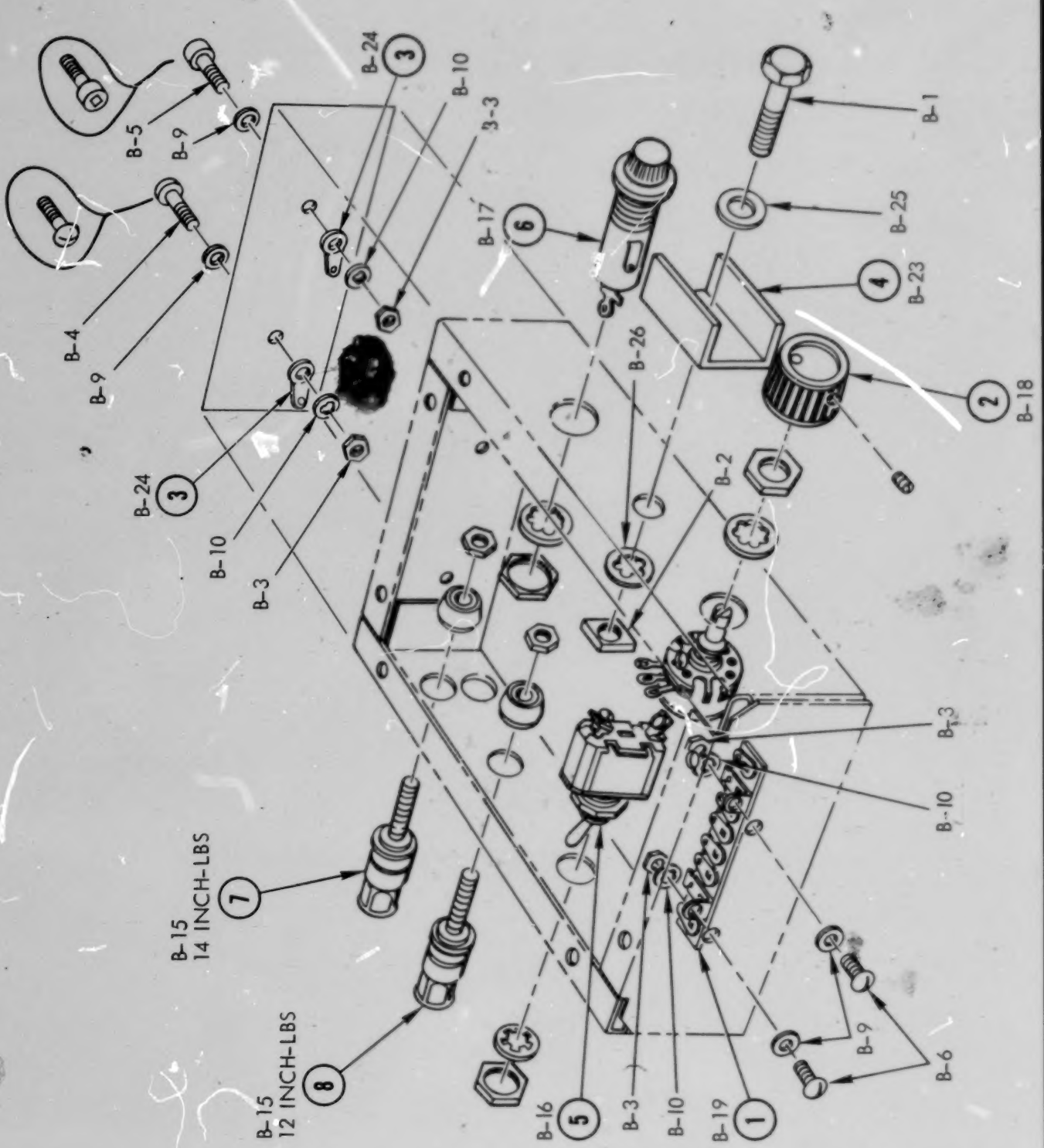


Exhibit 15. Assembly Drawing: Mechanical Assembly.

Specific learning objectives for the Mechanical Assembly program include:

a. How to interpret and work from mechanical assembly drawings.

b. How to use flat-blade, Phillips, and Allen screwdrivers.

c. How to use offset screwdrivers.

d. How to use box, open-end, crescent, and socket wrenches.

e. How to use a ratchet wrench.

f. How to use a torque wrench.

g. How to use a torque screwdriver.

The final examination for this program is shown in Exhibit 11. The teacher's checklist for the examination is shown in Exhibit 16.

2. Wire Preparation

In this program, the trainee is introduced to the tools and procedures for preparing both bare and insulated wire for assembly work. The trainee learns the names and correct uses of basic wire-preparation tools and equipment. He learns the nomenclature for different types of wires and wraps, how to strip insulated wire, and how to form and trim wraps.

The trainee learns the proper operation of a thermal wire stripper --- the first piece of electrical equipment to which he is introduced. Instruction in the use of the thermal wire stripper stresses the performance of proper safety procedures.

Student: _____

Instructor's Check List

FINAL EXAMINATION

MECHANICAL ASSEMBLY

Electronic Assembly Program No. 1

Item 1

____ A. BOLT

____ B. NUT

____ C. PHILLIPS SCREW

____ D. ALLEN SCREW

____ E. (SLOTTED) SCREW

____ F. FLAT WASHER

____ G. LOCK WASHER

____ H. CLAMP

Item 2

____ GROMMET

Item 3

____ A. PHILLIPS SCREWDRIVER or TORQUE DRIVER

____ B. ALLEN WRENCH

Exhibit 16. Examination Checklist: Mechanical Assembly.

Item 4

_____ A. SCREWDRIVER

_____ B. PHILLIPS SCREWDRIVER

_____ C. OFFSET SCREWDRIVER

_____ D. BOX WRENCH

_____ E. OPEN-END WRENCH

_____ F. RATCHET WRENCH

_____ G. TORQUE WRENCH

_____ H. TORQUE DRIVER

_____ I. CRESCENT WRENCH

Item 5

_____ A. 30 in/lbs.

_____ B. 68 in/lbs.

Item 6

_____ TO MAKE A CONNECTION EXACTLY AS TIGHT AS IT IS SUPPOSED TO BE.

Item 7

_____ 1. Torque driver set at 14 in/lbs.

_____ 2. Torque driver locked.

Exhibit 16. (Continued)

Item 8

NOTE TO INSTRUCTOR: IN ORDER TO SCORE THIS ITEM, THE INSTRUCTOR MUST WATCH THE STUDENT WHILE HE WORKS.

Step 1

_____ 1. Positions chassis according to drawing.

_____ 2. Begins with Assembly Step 1 --- gets binding post from Bin 15.

_____ 3. Removes fasteners before attempting installation.

_____ 4. Correctly locates binding post and fasteners on chassis.

_____ 5. Sets torque wrench at 14 in/lbs.

_____ 6. Locks torque wrench.

_____ 7. Uses soldering aid to hold binding post while tightening fasteners, and uses torque wrench correctly to tighten fasteners.

Step 2

_____ 1. Begins Step 2 --- gets grommet from Bin 20.

_____ 2. Inserts grommet in correct location.

Step 3

_____ 1. Begins Step 3 --- gets switch from Bin 16.

_____ 2. Removes fasteners before attempting installation.

_____ 3. Correctly locates switch and fasteners.

_____ 4. Selects appropriate wrench, and uses wrench correctly for tightening fasteners.

Exhibit 16. (Continued)

Item 8 (continued)

Step 4

_____ 1. Begins Step 4 --- gets fuse holder from Bin 17.

_____ 2. Removes fasteners before attempting installation.

_____ 3. Correctly locates fuse holder and fasteners.

_____ 4. Selects appropriate wrench, and uses wrench correctly for tightening fasteners.

Step 5

_____ 1. Begins Step 5 --- gets terminal strip from Bin 19, and correct fasteners: Phillips screws, flat washers, lock washers, hex nuts.

_____ 2. Correctly locates terminal strip and fasteners on chassis.

_____ 3. Selects appropriate wrench for holding nuts, and correct-size Phillips screwdriver.

_____ 4. Uses tools correctly for tightening fasteners.

Step 6

_____ 1. Begins Step 6 --- gets volume control from Bin 18.

_____ 2. Removes knob and fasteners.

_____ 3. Correctly locates volume control and fasteners.

_____ 4. Selects appropriate tools and uses tools correctly for tightening fasteners and set-screw in knob.

Exhibit 16. (Continued)

Specific learning objectives include:

a. How to identify different types of wire wraps.

b. How to form bare wire wraps with pliers.

c. How to form bare wire wraps with a soldering aid.

d. How to strip insulated wire with a mechanical wire stripper.

e. How to prepare a thermal wire stripper for use.

f. How to strip insulated wire with a thermal wire stripper.

g. How to trim wraps.

h. How to interpret wire gauge numbers.

An excerpt from the final examination for the wire preparation program is shown in Exhibit 17.

2. Assembly Soldering

The trainee learns eight different types of solder connections for connecting insulated wire to three different types of terminals. The criteria for soldering techniques are based on NASA specifications.[1] Again, safety procedures are stressed in the instruction of electrical operations.

Specific learning objectives include:

a. How to identify different types of soldering irons.

b. How to prepare soldering irons for use.

c. How to prepare and adjust the power supply for use with a soldering iron.

d. How to tin a soldering iron.

---

[1] National Aeronautics and Space Administration: Requirements for Soldering Electrical Connections, Document No. NHB 5300.4 (3A); Soldering Electrical Connections, Document No. NASA SP 5002; and Quality Requirements for Hand Soldering of Electrical Connections, Document No. NPC 200-4.

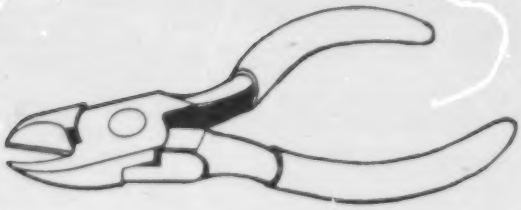
FINAL EXAMINATION

WIRE PREPARATION

Electronic Assembly Program No. 2

1. Write the name of each tool:

A _____

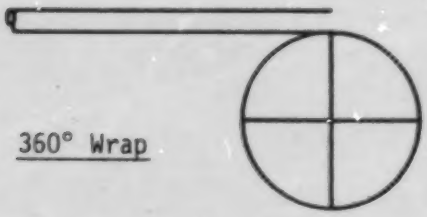


B _____

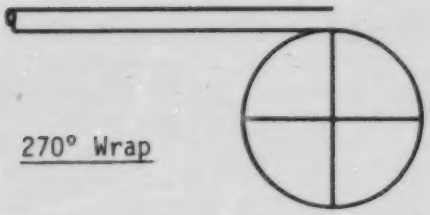
C _____

Exhibit 17. Final Examination (Excerpt): Wire Preparation.

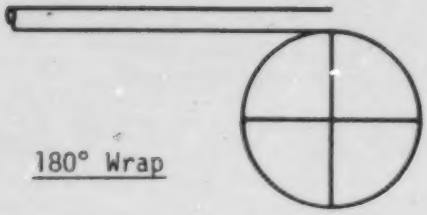
2. Finish the drawings:



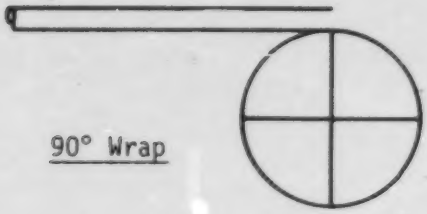
360° Wrap



270° Wrap



180° Wrap



90° Wrap

3. Which wrap is trimmed correctly?_____

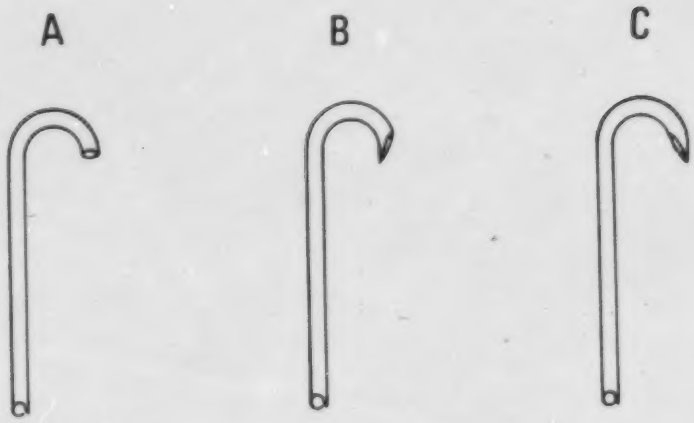


Exhibit 17. (Continued)

4. A big wire has a _____ gauge number.
BIG or SMALL

A small wire has a _____ gauge number.
BIG or SMALL

5. Read each step, then do it:

   1) Cut two pieces of AWG 20 bare wire. Make each wire 2 inches long.

   2) Make one small 180° wrap.

   3) Make one big 180° wrap.

   4) Trim the wraps.

6. Read each step, then do it:

   1) Cut a piece of AWG 20 bare wire. Make the wire 4 inches long.

   2) Get a bolt from Bin 1.

   3) Make a 270° wrap to fit the bolt.

7. Read each step, then do it:

   1) Cut four pieces of AWG 20 stranded insulated wire. Make each wire 6 inches long.

   2) Use the mechanical wire stripper to strip 1 inch of insulation from each wire.

8. Read each step, then do it:

   1) Cut four pieces of AWG 22 stranded insulated wire. Make each wire 4 inches long.

   2) Use the thermal wire stripper to strip 1/2 inch of insulation from each wire.

Exhibit 17. (Continued)

e. How to tin insulated, stranded wire.

f. How to make single and double solder connections to turret terminals.

g. How to make single and double solder connections to hook terminals.

h. How to make single and double side-entry solder connections to bifurcated terminals.

i. How to make top- and bottom-entry solder connections to bifurcated terminals.

One instructional technique used in this program requires the trainee to complete a drawing of each soldering procedure before he actually attempts the procedure. Exhibits 18 and 19 show textbook and filmstrip frames which are typical of those used to implement this technique.

Textbook Frame 158, in Exhibit 18, requires the trainee to complete the drawing without reference to any filmstrip picture. Prior to Frame 158, however, the trainee has had the opportunity of completing an identical drawing by copying actual photographs of the soldering procedure depicted.

158. Make a drawing of the soldering iron and the solder:

1) Put the tip of the soldering iron on the base of the term terminal. Do not touch the wire or the terminal posts.

Touch a small amount of solder where the iron touches the base.

2) Touch the solder to the base on the side opposite the iron.

Do not move the iron.

3) Touch the solder to the base on the other side of the wire.

Do not move the iron.

4) Touch the solder to the end of the wire.

Slowly move the solder over the end of the wire to the hole, and fill the hole with solder.

Quickly remove the solder and the iron at the same time.

158-ANSWER

Exhibit 18. Programmed Textbook (Excerpt): Assembly Soldering.

Exhibit 19 shows filmstrip Frame 158-Answer --- the drawing as it must be correctly completed.

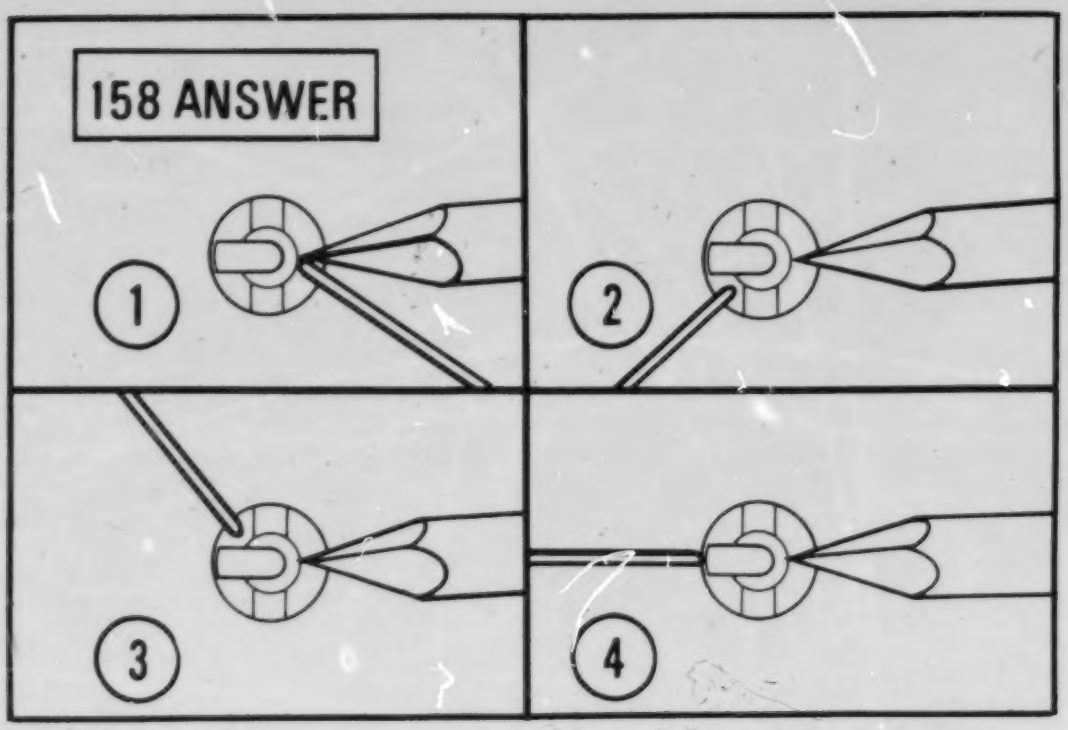


Exhibit 19. Filmstrip Answer Frame: Assembly Soldering.

4. Wire Installation

In this program, the trainee learns to install wires on a terminal board. In so doing, he learns to read and work from assembly drawings representative of those commonly used in industry. Exhibit 20 shows the set of drawings used for this program and the Wire Harness Building and Component Installation programs which follow. As the trainee works through these programs, he builds an electronic assembly chassis on a terminal board.

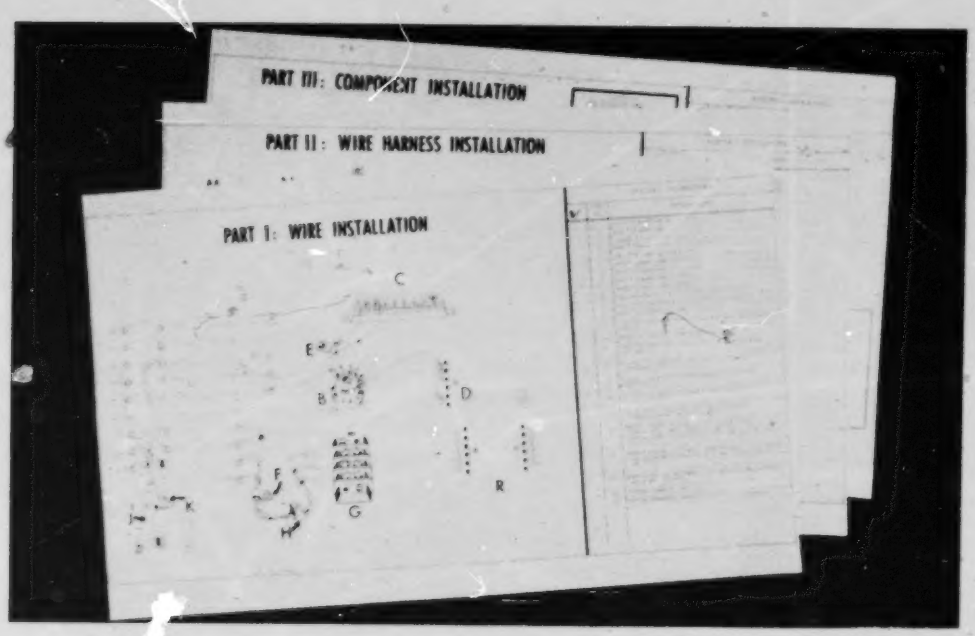


Exhibit 20. Assembly Drawings: Programs 4-through-7.

Exhibit 21. Trainee. California School for the Deaf, Riverside.

Exhibit 21 shows a trainee working on the chassis in the Wire Installation program.

Specific learning objectives for the Wire Installation program include:

a. How to interpret and work from electronic assembly drawings.

b. How to solder wire to perforated terminals.

c. How to dress wires.

d. How to prepare and install multi-conductor cable.

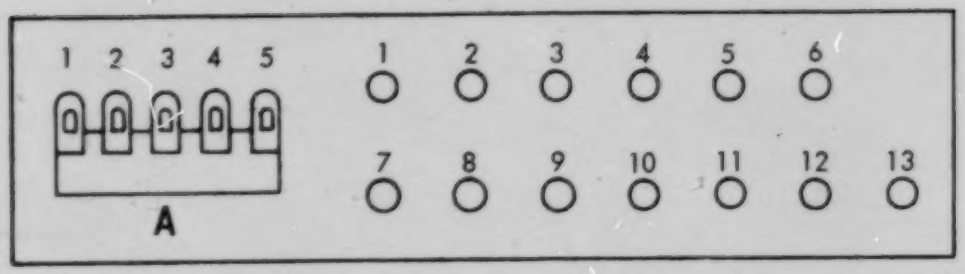
e. How to crimp terminal lugs, insulated splices, wire joints, and connector contacts.

Exhibit 22 shows the final examination for this program.

FINAL EXAMINATION

WIRE INSTALLATION AND WIRE DRESSING

Electronic Assembly Program No. 4



1. Do all of the Steps in the Assembly Instructions:

ASSEMBLY INSTRUCTIONS		
V	STEP NO.	INSTRUCTIONS
	1	AWG #20 BARE WIRE (USE INSULATION) 1(NS)/7(S)
	2	AWG #20 BARE WIRE 8/9/10 (NS)
	3	AWG #20 INSULATED WIRE 1/11 (S)
	4	AWG #20 INSULATED WIRE 2(S)/12(NS)
	5	CUT 6" MULTI-CONDUCTOR CABLE. STRIP ONE END 2-1/2" CUT INNER CONDUCTORS TO LENGTH: G 2-1/2", BK 2", WH 2", R 1-1/2"
	6	INSTALL MULTI-CONDUCTOR CABLE: GN/5(S), BK/6(S), WH/12(S), R/13(S)
	7	AWG #20 BARE WIRE A-1/A-2 (S)

2. Get a terminal lug from Bin 51. Crimp the terminal lug to a piece of AWG #20 insulated wire.

3. Get a splice from Bin 52. Crimp together two pieces of AWG #20 insulated wire.

4. Get a wire joint from Bin 53. Crimp two pieces of AWG #20 insulated wire in the wire joint.

5. Get a connector contact from Bin 66. Crimp the connector contact to a piece of AWG #20 insulated wire.

Exhibit 22. Final Examination: Wire Installation.

5. Wire Harness Building and Installation

The trainee learns to read and work from a type of wiring diagram which is most commonly used in industry for building and lacing wire harnesses. Exhibit 23 shows this wiring diagram, together with the wire harness which the trainee builds as he works through the instructional program. The diagram serves as a full-scale matrix (harness board) for routing and spot-tying the wires in the harness.

Specific learning objectives for the Harness Building program include:

a. How to interpret and work from a harness board wiring diagram.

b. How to install wires on a harness board.

c. How to locate, make, and stake spot ties.

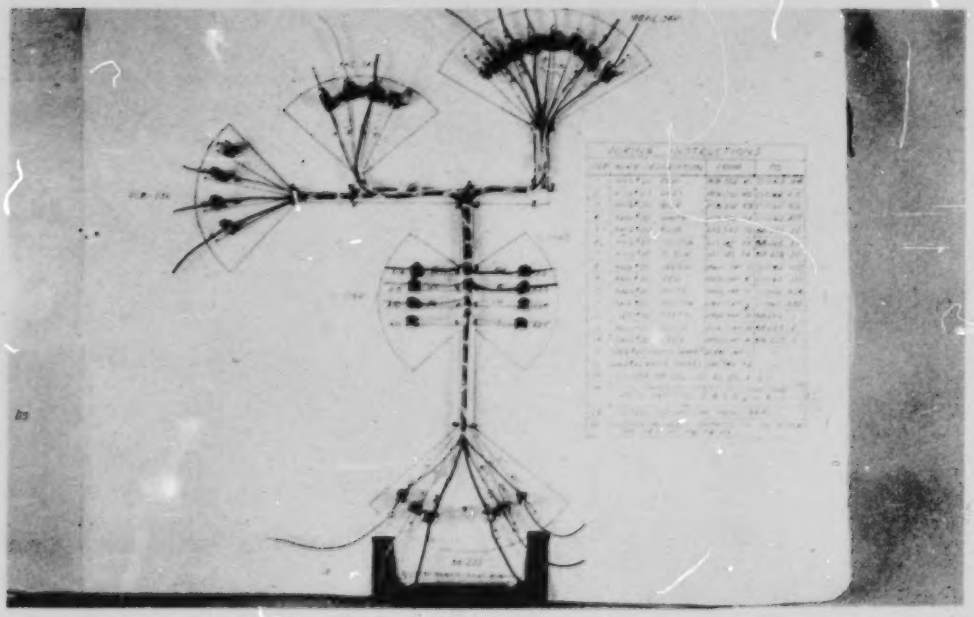


Exhibit 23. Harness Board: Wire Harness Building and Installation.

d. How to install wire markers.

e. How to solder connector contacts to wires.

f. How to solder connector contacts to connectors

g. How to install and remove removable contacts.

h. How to install wires in solder-cup connectors.

i. How to install a harness on a terminal board chassis.

To complete the Harness Building program, the trainee installs the harness he has built on the terminal board chassis he began building in the Wire Installation program. Exhibit 24 shows what the chassis looks like at the end of the Harness Building program.

Exhibit 25 shows trainees building their harnesses.

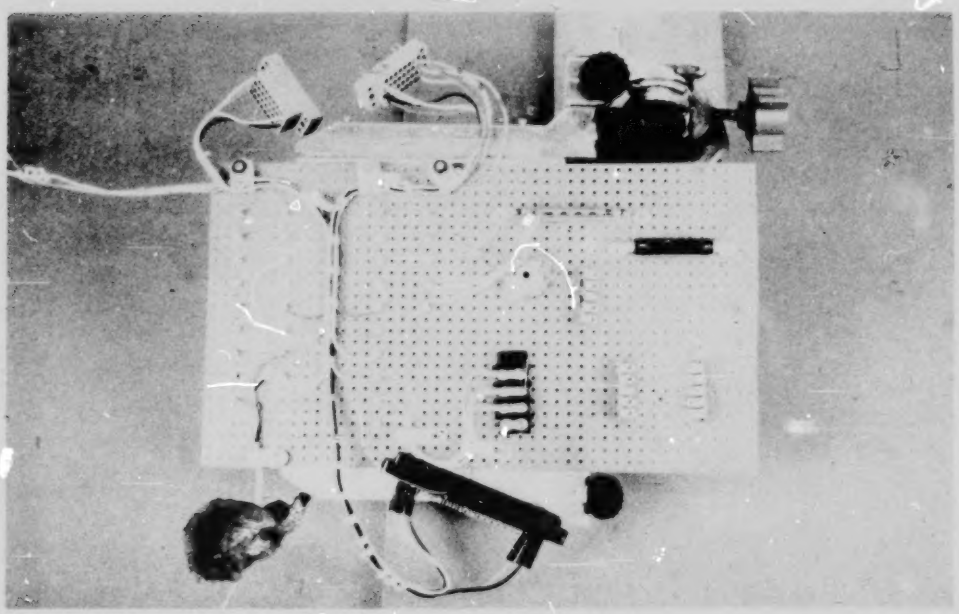


Exhibit 24. Electronic Assembly at Completion of Harness Building Program.

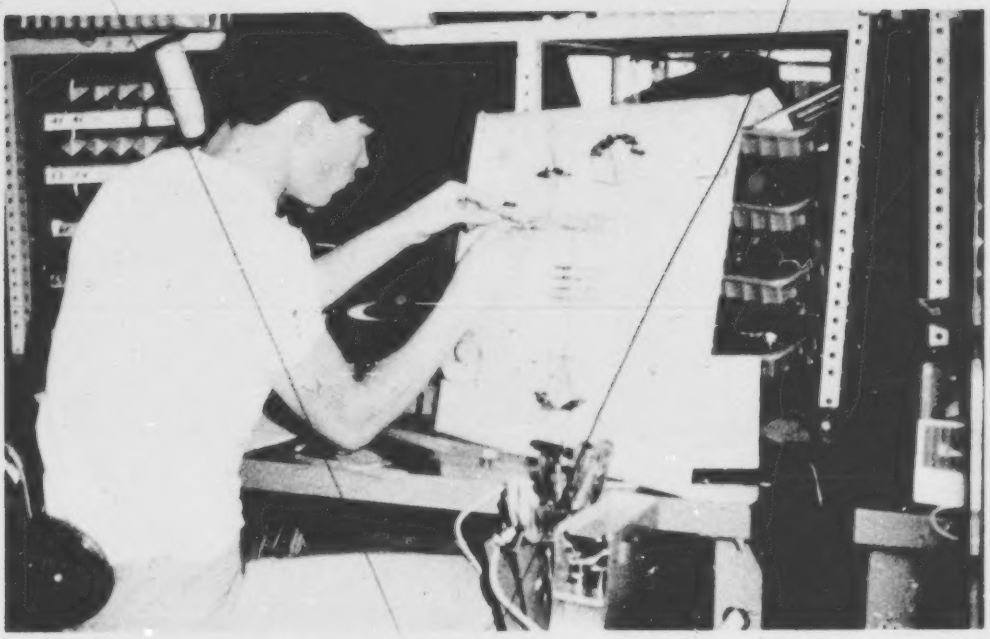


Exhibit 25. Trainees. California School for the Deaf, Riverside.

6. Component Installation

In this program, the trainee learns to work from component installation drawings to install transistors, resistors, capacitors, etc., on both terminal board chassis and printed circuit boards. Exhibits 5, 6, 7, 12, and 13 show sample textbook and filmstrip frames, together with a page from the teacher's checklist, the final examination, and a page from the examination checklist.

Exhibit 26 shows a trainee working on the Component Installation program.

Specific learning objectives for the program include:

a. How to interpret and work from component installation drawings.

b. How to position resistors and other components.

c. How to solder components to turret, perforated, and T-terminals.

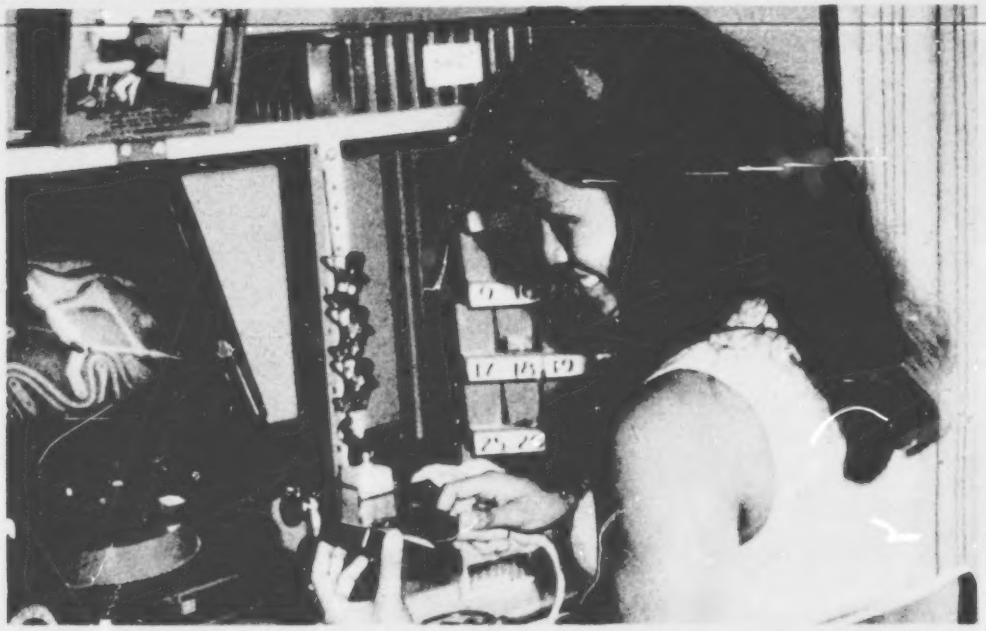


Exhibit 26. Trainee. California School for the Deaf, Riverside.

d. How to make multiple component connections, including stacking.

e. How to install components on printed circuit boards.

7. Electronic Assembly Rework Techniques

Electronic assembly rework primarily involves repairing connections and removing and replacing terminals, wires, and components which have been improperly installed or damaged, or which must be changed because of design modifications originating after assembly has begun.

Specific learning objectives include:

a. How to remove solder from a connection using a solder draw or a solder-removing syringe.

b. How to rework (repair) solder connections.

c. How to remove and replace wires between terminals.

d. How to remove and replace wires in a wire harness.

e. How to remove turret and bifurcated terminals from a terminal board.

f. How to install turret and bifurcated terminals.

g. How to rework multiple connections.

h. How to remove and replace components on a terminal chassis.

i. How to remove and replace components on a printed circuit board.

Exhibit 27 shows the final examination for this program. It is different from all of the others, in that the teacher must watch the trainee work throughout the entire examination. Most of the questions require the trainee to do removal and replacement work which will leave the electronic chassis looking exactly the same as it did before rework began.

FINAL EXAMINATION

REWORK TECHNIQUES

Electronic Assembly Program No. 7

NOTE TO STUDENT: YOUR TEACHER WILL WATCH YOU WORK DURING THE EXAMINATION.

1. Put your chassis in the vise. Remove component A-3/A-13. Remove the solder from A-3 and A-13 with a solder draw. Get a replacement component from Bin 72. Install the replacement component to terminals A-3 and A-13.

2. Remove wire A-24/D-5 from the chassis. Remove the solder with a solder-removing syringe. Install a replacement wire between terminals A-24 and D-5. Make the replacement wire the same as the wire you removed.

3. Choose any wire in the harness. Connect a replacement wire to the wire in the harness. Pull the wire out of the harness, and install the replacement wire.

4. Choose any wire in the harness. Cut and tie both ends of the wire. Install a replacement wire alongside the harness.

5. Remove a bifurcated terminal from a terminal board.

6. Get a bifurcated terminal from Bin 79. Swage the terminal to any hole in the terminal board.

7. Put your printed circuit board in the vise. Choose any component with unclinched leads. Remove the component.

8. Choose any component on the circuit board with clinched leads. Remove the component. Re-install the component you removed in the same terminal holes.

Exhibit 27. Final Examination: Electronic Assembly Rework Techniques.

E. Administrative Characteristics

1. Length of the Curriculum

The programmed textbooks contain approximately 1,250 frames of instruction, as do the accompanying filmstrips. This includes Answer frames. There are only seven programmed textbooks, but 18 filmstrips. Because each program averages approximately 180 frames, filmstrip content has been split into two or three filmstrips per program in order to make the filmstrips easier to handle.

Experience with tryout populations indicates that a mean time of approximately 100 hours is required to complete the entire course of instruction, including final examinations. Because each trainee proceeds at his own pace, however, individual completion times may vary widely. A fast trainee may complete instruction in 50 hours or less. A slow individual may require 200 hours or more.

Exhibit 28 shows a summary of achievement data for a group of seven high school students who were in a tryout population for the last four programs in the series. The students are listed in order of the quality of the electronic assembly workmanship which they produced. The best workmanship is ranked No. 1. The next two best students produced work of equal quality, so they are both ranked No. 2.

The data indicated that the students who produced the best workmanship also tended to work the fastest and have the highest final examination scores. However, the data do not show one important variable --- the length of individual periods of instruction. The two top-ranked students, Lance Y. and Mark S., worked daily three-hour class periods. The remainder of the group had only a 90-minute class period each day.

ELECTRONIC ASSEMBLY

Tryout of Self-Instructional Programs 4-through-7

California School for the Deaf, Riverside, California

June 16 through July 25, 1969

BEHAVIORAL AND ACHIEVEMENT DATA

WORK-MANSHIP	STUDENT	AGE	GRADE	WEXLER I.Q.	GRAY-VOTAW-ROGERS			ELECTRONIC ASSEMBLY PROGRAMS	
					LANG.	READING		AVERAGE HOURS PER PROGRAM	EXAM SCORES (MEAN)
						VOCAB.	COMP.		
1	Lance Y.	17-7	9	91	5.6	4.8	5.9	7.8	95.5%
2	Mark S.	16-6	9	120	6.8	5.3	4.9	6.6	91.7
2	Geraldine L.	17-2	10	---	3.5	4.1	4.0	8.8	87.7
3	Robert B.	17-11	9	117	4.3	3.5	4.2	9.0	88.0
4	Ken S.	16-2	8	109	4.1	4.8	6.8	7.1	90.5
5	Sharon I.	15-8	9	100	4.3	5.0	4.9	13.2	88.5
6	Joanne M.	17-6	9	87	3.4	4.4	3.5	13.0	64.0

Exhibit 28. Behavioral and Achievement Data: Tryout of Programs 4-through-7.

Depending on the length of the individual periods of instruction, the curriculum may be programmed for a full year of administration in a high school schedule, for one semester, or for less time under special circumstances. The longer the daily period of instruction, the faster the pace tends to be.

An important administrative consideration is what to do with the trainee who finishes early. A number of choices exist. The fast learner might serve as an assistant to the teacher, replenishing hardware stock at the workbenches, building work samples, and tutoring the slower learner. The fast learner also might be given assembly projects to reinforce what he has learned with further work experience, improve his skills, and assure his ability to transfer what he has learned to work situations which are not identical to his learning experiences.

Ideal projects for the trainee who finishes early may be found among commercially available electronic assembly kits. Exhibit 29 shows one such trainee assembling a capacitor tester. The

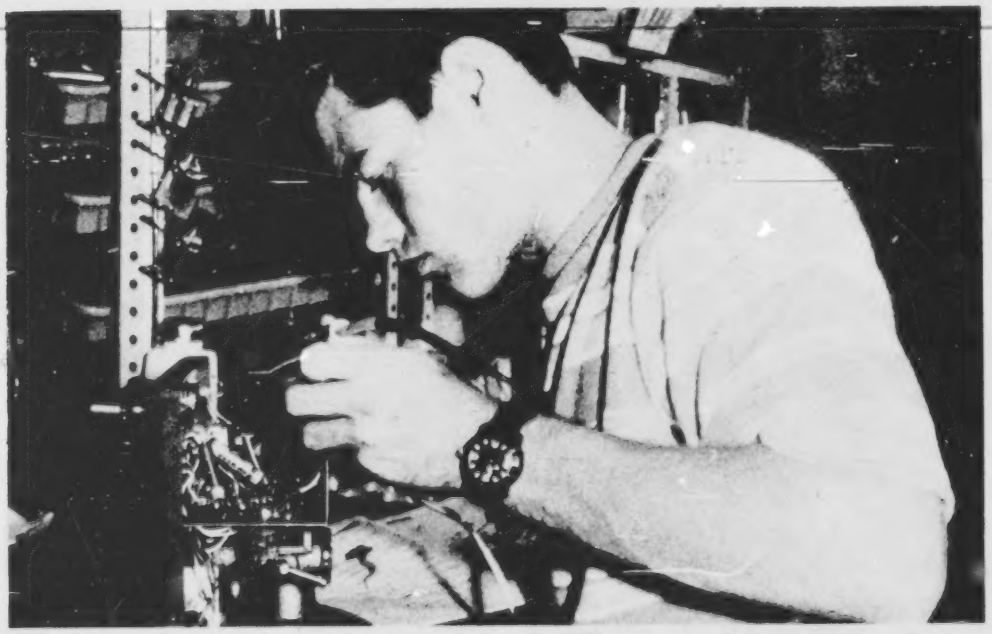


Exhibit 29. Trainee. California School for the Deaf, Riverside.

kit for this project contained a chassis, parts, and assembly drawings which were quite different from those used in the instructional program. Nonetheless, the trainee was able to complete the assembly with no significant problems, and the capacitor tester was subsequently put to practical use as workshop equipment.

2. Trainee Entry Requirements

The training system was designed for the instruction of both boys and girls of normal intelligence. Good visual acuity and digital dexterity are required. A reading grade level of at least 3.5 is necessary.

Any appropriate vocational aptitude test might be used for selecting trainees who are most likely to succeed in the course. The Mechanical Assembly program, which is the first instructional program in the series of seven, also may be used as a screening device. If a trainee is not capable of completing the course, it will become very apparent within the first four or five hours of instruction.

Ideally, the entering trainee should be motivated to qualify for the job of electronic assembler, or at least interested in finding out what the job is all about. The system is self-motivating only in the sense that it will tend to maintain and strengthen whatever interest and motivation a trainee begins with. If an individual is not interested in electronic assembly work, there is little reason for him to be subjected to the instruction.

A high threshold for frustration also is desirable. Tryout experience indicates, however, that a trainee's behavior in this training system may be quite different from his behavior in other types of instructional situations.

A trainee with a low attention span in the conventional classroom may spend hours on end absorbed in programmed self-instruction at the electronic assembly workbench. The trainee shown in Exhibit 30 had a school-wide reputation as a difficult student and a troublemaker. In conventional classrooms, her attention span was 15 or 20 minutes. She then would not only completely lose interest, but also would begin distracting other students with interruptive behavior.

At the electronic assembly workbench, however, this student consistently worked full 90-minute periods with rapt attention, and refused to be distracted even by events (such as the arrival of visitors) which tended to interrupt the attention and the work of other trainees. She appears as Geraldine L. --- the third highest-ranking achiever --- on the data sheet shown in Exhibit 28.

Exhibit 30. Trainee. California School for the Deaf, Riverside.

Tryout experience indicates that success in the training system results from a combination of factors. The most important of these is probably the motivation that the trainee starts with. The overall top-ranking trainee on the data sheet in Exhibit 28 was a low achiever in almost all other schoolwork, and was characterized by his instructors as a time-waster. It may be noted that his I.Q. score of 91 is only four points higher than that of the lowest-ranking trainee, who also had the lowest I.Q. score.

3. Teacher Requirements

Although the teacher's attention may be required no more than about 10 per cent of an individual trainee's time, it is essential that the teacher be immediately available whenever a trainee needs him. For this reason, the constant presence of the teacher in the classroom is required, and it is not feasible for a teacher to administer the system while conducting other classroom activities with other students.

An experienced teacher should be able to effectively supervise the work of 10 trainees, each at his own workbench. A highly experienced teacher might be able to handle a group of 12 or more, particularly during the second half of the series of seven programs, although he probably would require the assistance of a teaching aid during the first two or three programs when demands upon the teacher are heavier.

For the initial administration of the system, a class size of no more than six is recommended. The teacher will be kept quite busy.

The most important qualification for the teacher is a knowledge of electronic assembly techniques and standards. The best qualified teacher is an individual with experience as an electronic assembler or as an assembly supervisor or inspector in industry.

Because the programmed textbook/filmstrip materials bear the burden of instruction, prior teaching experience is not essential. And because of the high communication content of the programmed textbook and filmstrip materials, previous experience in communicating with the deaf is not a requirement.

It is possible that a teacher with no previous experience in electronic assembly might acquire the requisite skills by successfully working through the Electronic Assembly Self-Instructional Training System before administering it. In order for this to happen, however, a fully-qualified instructor would be required to administer the system to the prospective teacher.

4. Cost of Instruction

The direct cost of administering the Electronic Assembly Self-Instructional System consists of the teacher's salary, the capital investment in electronic assembly hardware and filmstrip projection equipment, and the recurring costs of expendable materials.

A single workbench can be installed, complete with electronic assembly gear, filmstrip projector, and screen, for $1,000 or less, depending on the exact types of workbench and projection equipment selected. Multiple installations will cost less because of volume discounts.

Of $1,000 spent for a workbench installation, approximately $350 is required for the workbench itself, workbench accessories, i.e., bins, racks, trays, spool holders, etc., and a work chair. A complete set of electronic assembly tools and equipment for a workbench costs approximately $450. This leaves $200 for the filmstrip projector and screen.

Any conventional 35mm filmstrip projector may be used for the system, although a machine with forward and reverse remote control is recommended. Any conventional rear-projection table-top viewing screen may be used. However, a large screen is desirable. The projector must be equipped with a wide-angle lens (3-1/2 inch or shorter focal length) in order to minimize the distance from the projector to the screen.

The cost of expendable electronic assembly parts and materials may range from $12 to $25 per trainee, depending on how much of the trainee's work samples are salvaged and reused. In addition, planning budgets should include a cost of $10 per trainee for the replacement of projector bulbs. Representative bulb life is about 50 hours, and bulbs typically cost about $5.00 each.

Instructional filmstrips and the teacher's checklists are reusable, but the programmed textbooks, final examination materials, and most of the other text materials are not.

Instructional filmstrip and text materials are distributed through the Media Services and Captioned Films Branch, Bureau of Education for the Handicapped, U.S. Office of Education. Cost of these materials must be obtained from the Media Services and Captioned Films Branch.

IV. DEVELOPMENT OF THE TRAINING SYSTEM

A. Antecedents of the Project

1. War Training Program, Division of Visual Aids for War Training

The conceptual prototype of the Electronic Assembly Self-Instructional Training System for the Deaf dates from World War II. At that time, to help cope with the training demands of wartime production, the United States Office of Education established a Division of Visual Aids for War Training. Between January 1941 and June 1945, the War Training Program of the Division of Visual Aids for War Training produced 457 film-based instructional units for skill training in 15 different skill areas.[2]

The title and the number of instructional units in each skill area series were as follows:

Series Title	Number of Units
1. Machine Shop Work	125
2. Aircraft Work	77
3. Shipbuilding Skills	40
4. Precision Wood Machining	41
5. Engineering	23
6. Electrical Work	28
7. Problems in Supervision	22
8. Nursing	14
9. Foundry Practice	14
10. Refrigeration Service	15
11. Farm Work	18
12. Welding Procedures	5
13. Plastics	10
14. Optical Craftsmanship	6
15. Automotive Operation and Maintenance	19
Total	457

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[2] Brooker, Floyde E. Training Films for Industry: Final Report on the War Training Program of the Division of Visual Aids for War Training. Bulletin No. 13. Washington, D.C.: Federal Security Agency, U.S. Office of Education, 1946. 103 p.

The basic item in each instructional unit was a 16mm sound motion picture. But the approach to the production of these films represented a major departure from the conventional training films of the era: 432 of the films were accompanied by a coordinated 35mm filmstrip and an instructor's manual in a visual aids package designed as a totally integrated instructional system. The content of these materials was behaviorally oriented, in that their use was intended to result in the acquisition of specific job skills rather than merely teach "about" the jobs involved. The only exception to this objective was in the series dealing with supervision. Here, major emphasis was on developing correct attitudes toward problems of supervision rather than instructing specific skills in solving those problems.

The scope of each visual aids unit was limited to a single job operation. Typically, the motion picture showed the step-by-step procedures required for the performance of that operation. The filmstrip, incorporating excerpts from the motion picture, not only provided step-by-step review of motion picture content, but also incorporated question-and-answer and other types of learner participation frames. The manual guided the instructor in the use of the motion picture and filmstrip, and provided additional instructional data.

Motion picture content was kept as compact as possible. Static subject matter which could be handled just as well or better in a filmstrip was either given short exposure or entirely eliminated in the motion pictures. Thus, because of their limited objectives, and because they were designed to be seen several times if necessary for full mastery of their content, these motion pictures were in a very real sense the conceptual and developmental predecessors of today's single-concept loop films.

The filmstrips averaged 40 frames in length. Most of the frames were identical in content to scenes in the accompanying motion picture. Captions on each of these frames consisted of a short statement or question designed both to provide a review of motion picture content and to serve as a stimulus for group discussion of key teaching points. Other filmstrip frames showed charts, diagrams, test questions and answers, etc.

The instructor's manual supplied a detailed plan for the most effective use of each motion picture and filmstrip combination. It contained an outline of the motion picture, together with the numbers of the filmstrip frames relating to specific steps in the motion picture outline. Utilization data included suggested techniques for overall presentation of the content of each visual aids unit, follow-up activities for maximizing the effectiveness of film presentations, and a list of related motion pictures and filmstrips.

The content of the instructor's manual represented a significant departure from existing practices in that it was limited to the content of the motion picture and filmstrip which it accompanied. The primary function of the manual was to organize motion picture, filmstrip, and teacher activities into an instructional unit, and to present the teacher with a strategy for most effectively using the unit as intended --- as a coordinated whole.

Although the visual aids units were designed for group instruction, a great many learner-centered techniques were incorporated into the film materials to induce the greatest possible degree of trainee involvement. For example, first-person camera angles were used in motion pictures to show the performance of a task from the viewpoint of the individual doing the work. First-person, stream-of-consciousness commentary and other intimate types of narration were used as the sound tracks for a number of films.

Participation frames in the filmstrips often were highly imaginative. For example, the outlines of an automobile engine might be depicted in white lines on a black background. This frame could be projected onto a blackboard, where the outline would show up very satisfactorily, and a trainee would be asked to chalk in the wiring system of the automobile engine.

2. Learner-Centered Audiovisual Instruction in Industry

The War Training Program of the Division of Visual Aids for War Training was a landmark in the movement toward the concept of audiovisual instructional systems for vocational training. In many ways, it was ahead of its time. More than ten years were to pass before the scope and significance of its achievement were matched by the introduction of audiovisual machine instruction on manufacturing assembly lines in an industrial approach to improving production efficiency.[3]

In this application, as depicted in Exhibit 31, coordinated slide/tape presentations were designed to provide a worker with step-by-step instructions which led to the completion of the assembly work. Each workbench was equipped with its own slide-projection and audiotape playback machine. The worker received audio instructions through a light-weight headset. The pace of presentation might either be preprogrammed or controlled by the worker.

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[3] Persselin, Leo E. An Approach to System Design in Audiovisual Instruction., Ph.D. dissertation, University Microfilms Order #68-5878, University of Southern California, 1967. 609 p. See "Audiovisual Instructional Systems in Industry," pp 238-283, for an extensive discussion of the Hughes and other industrial and vocational instructional systems applications; also "A Training System for Industry," pp 481-504, for a more elaborate description and evaluation of the War Training Program of the Division of Visual Aids for War Training discussed in the foregoing pages.

The first company to formally implement this system was Hughes Aircraft Company, Culver City, California. Initially, beginning in 1951, the company used colored slides only, with no audio accompaniment. The slides illustrated each step an assembler had to perform in long, involved series of assembly operations. The application was immediately successful. Previously required instruction time dropped, production output rose, and the number of rejects due to faulty work plummeted.

During the next few years, as the audio component was added, Hughes engineers began designing their own audiovisual hardware, and by the end of 1957 the company had produced its first completely self-contained coordinated slide and tape presentation device. This machine automatically changed slides in response to either an electronic pulse recorded on the audio tape or the operator's pushing a buttom.

By mid-1960, almost 800 of the Hughes devices were in use on assembly lines in the company's manufacturing plants in El Segundo and Fullerton, California, and Tucson, Arizona. (Exhibit 32) Through use of the system, electronic assembly workers consistently were able to achieve from 90 to 100 per cent of work standards. Without the audiovisual aid, the most experienced assemblers were able to achieve only 60 per cent of the work standard, with less experienced operators falling far below this figure. Defect rates were slashed as much as 99 per cent, and rework was virtually eliminated.[4]

Other companies also began using the approach pioneered by Hughes. By 1960, comparable slide/tape presentation devices had been built and were being used by Northrop Aircraft Corporation, Hawthorne, California; North American Aviation, Inc., Anaheim, California; Collins Radio, Inc., Cedar Rapids, Iowa; Bendix Corporation, North Hollywood, California, and Teterboro, New Jersey; the Boeing Company, Seattle, Washington; Magnavox,

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[4] "Robot Instructors Win Friends and Speed Assembly," Factory, November 1960.

Inc., Fort Wayne, Indiana; Ampex Corporation, Redwood City, California; and Lear, Inc., Grand Rapids, Michigan. In 1961, Hughes and a number of other companies began to market their audiovisual machines and program development services commercially. Within a year, the system was being used by dozens of companies throughout the country.

Effectiveness of the system was typified by the experience of Republic Aviation Corporation, Farmingdale, Long Island, New York. At Republic, audiovisual instruction on the assembly line boosted productivity, cut training time, and slashed assembly costs by more than 40 per cent. In the company's manufacturing engineering section, missile-guidance subassembly modules which previously had taken 15 to 18 hours to complete were cut to nine hours of assembly time.[5]

It must be clearly understood that the industrial applications noted above were those of a performance aid rather than a learning aid. The slide/tape presentation was, in effect, an audiovisual blueprint. The worker already needed to know the basic assembly skills required for following that blueprint. The objective of the instructional program was improved production, not learning. The system proved most effective where learning on the part of a worker not only was unnecessary, but might even be undesirable and detrimental to further production.[6] At a time when the appearance of "teaching machines" was creating considerable stir in the educational community, the industrial slide/tape performance aid was proving to be the perfect "non-teaching machine."

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[5] "Color-Sound Slides Speed Assembly," American Machinist/Metalworking Manufacturing, April 30, 1962, pp 108-110.

[6] Persselin, Leo E. "Auto-Instructional Technology and Data Processing," Data Processing for Management, VI, No. 4, April 1964, pp 9-12.

Inevitably, however, industrial users of the audiovisual performance aid began to experiment with learning applications. It was apparent that some of the inherent advantages of slide/tape presentation for assembly line production might pay off just as well in learning situations. As a result, by mid-1963 learning aid programs were being used by many of the companies which had experimented successfully with performance aid applications. None of these early programs, however, incorporated the basic features of learner response, immediate feedback, etc., which typify programmed learning.

The early industrial slide/tape learning aid programs were essentially equivalent to the sound-filmstrip presentations of the period, except that they were designed for individual viewing and pacing by the viewer through use of one of the machines designed for assembly line use. Program content was typically in the form of a straightforward presentation. No text material accompanied the slides and tapes, no question-and-answer content was included, and the viewer was required to do nothing but watch passively during program presentation. For the most part, the programs were intended as supplementary, non-essential materials for introduction or review. Typically, their running time was short.

Many of the early learning aid programs dealt with basic electronic assembly skills. Hughes Aircraft Company, for example, produced a series of eight learning aid programs with the following titles: Use and Care of Small Tools, Assembly Soldering, Etched Card Assembly, Mechanical Assembly, Component Installation, Wire Installation, Harness Building, and Rework Techniques. Each program averaged approximately 40 slides in length. The individual presentation time of each program ranged from 15 to 28 minutes, depending on the running time of the individual tape. Total presentation time for all

eight programs was two-and-a-half hours. Since no learner response was required during program presentation, it was not essential that the programs be viewed at an electronic assembly workbench.

Despite the limited learning applications of these early industrial programs, they were in fact the immediate developmental predecessors of the Electronic Assembly Self-Instructional Training System for the Deaf. The industrial experience stimulated research into the use of the learner-centered audiovisual technique both as a learning aid and as a performance aid for the handicapped. The first impact on special education was not on education of the deaf, however, but on instruction for mental retardates.

3. Programmed Learning for Special Education

Beginning in the early 1960's, a body of research findings began to be established which showed that learner-centered audiovisual programs could substantially facilitate both learning and retention by the mentally retarded. It was demonstrated that the Hughes synchronous slide/tape device, providing individual instruction at the learner's own pace, could significantly improve the learning of job skills by retardates.[7] Research projects also indicated that sound motion pictures and 8mm film loops could significantly contribute to the learning of job skills.[8, 9]

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[7] Neuhaus, E.C. "Programmed Audio-Visual Training for the Mentally Retarded," Trends in Programmed Instruction. Edited by Gabriel D. Ofiesh and Wesley C. Meierhenry. Washington, D.C.: National Education Association, 1964. pp 98-103.

[8] Goldstein, Edward. Selective Audio-Visual Instruction for Mentally Retarded Pupils. Springfield, Ill.: Charles C. Thomas Company, 1964. 96 p.

[9] Bitter, James A., and Bolanovich, Daniel J. "Job Training of Retardates Using 8mm Film Loops," Audiovisual Instruction, XI, No. 9, November 1966, pp 731-732.

Research findings were not limited to job skills. A self-instructional program incorporating the use of an automatic slide projector was shown to substantially increase the retention of vocabulary learned by retardates.[10] A ten-week program primarily consisting of 440 slides, tape recordings, and lesson plans improved the results of instruction in social adjustment.[11]

In performance aid applications, it was demonstrated that industrial assembly line techniques of synchronous slide/tape presentation could be used very effectively in sheltered workshop situations, both for the mentally retarded and other handicapped populations. Exhibit 33 shows newspaper clippings

Look, Listen & Learn
Audio-Visual Training

NEW MANPOWER FOR INDUSTRY
...THE MENTALLY RETARDED

Videosonic - Most Appropriate

Exhibit 33. Newspaper Clipping: "Look, Listen & Learn, Audio-Visual Training."

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10 Vergason, Glenn A. "Retention in Educable Retarded Subjects for Two Methods of Instruction," American Journal of Mental Deficiency, LXX, 1966, pp 683-688.

11 Edmonson, Barbara, et al. "Teaching Retarded Adolescents to Interpret Social Cues." Paper presented at American Association of Mental Deficiency Convention, Chicago, Illinois, 1966.

describing one such application at Opportunities Unlimited, Inc., Long Island, New York.[12]

During this same period of time, research into picture-based, learner-centered instructional systems for the deaf was focused on language learning and speech teaching. Experiments with programmed learning were indicating that programmed self-instructional approaches could be extremely effective for deaf education.[13] Based on these findings, and following a need assessment in 1963, Captioned Films for the Deaf, U.S. Office of Education, in 1964 created Project LIFE (Language Improvement to Facilitate Education of Hearing Impaired Children).[14]

Project LIFE had as its goal the development of programmed language materials to supplement or complement language learning for hearing impaired children starting at the pre-school level. Content was to be developed around three basic concepts: the concepts of self, physical environment, and social relationships. Instructional media were to evolve in the form of coordinated picture books, concept-oriented picture dictionaries, workbooks, and programmed filmstrips.

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12 "Look, Listen & Learn, Audio-Visual Training," Long Island Commercial Review, Garden City, L.I., N.Y., May 8, 1963.

13 Beckmeyer, T. "Application of Programmed Instruction to Remedial Reading for the Deaf," Volta Review, LXV, 1963, pp 415-417; Falconer, G. A. "A Mechanical Device for Teaching Word Recognition to Young Deaf Children." Doctoral dissertation, University of Illinois 1959; Fehr, J. "Programming Language for Deaf Children," Volta Review, LVIV, 1962. pp 14-21; Karlsen, B. "Teaching Beginning Reading to Hearing Impaired Children, Using a Visual Method and Teaching Machines," University of Minnesota, U. S. Office of Education Project No. 1204, 1966; etc.

14 Ongoing Project LIFE activities are sponsored by the Media Services and Captioned Films Branch, Bureau of Education for the Handicapped, U. S. Office of Education. Project LIFE is administered by the National Association, 1156 15th Street, N.W., Washington, D.C. 20036. Project Director is Dr. Glenn S. Pfau.

The use of all of the other Project LIFE materials was based on the programmed filmstrips. These were designed for individualized self-instruction through the use of a specially designed control-and-response console to which a conventional filmstrip projector might be connected. The learner views filmstrip content via a table-top rear-projection screen, and responds to instruction by means of multiple-choice push buttons. Programming is linear. Feedback is by signal light.

Exhibit 34 shows the Project LIFE programmed filmstrip arrangement in a study carrel. The projector is on the left. A small rear-projection screen is on the right. The control-and-response console is a developmental model. The model currently in use is more highly refined in appearance, but basic design aspects and functional characteristics are essentially the same.

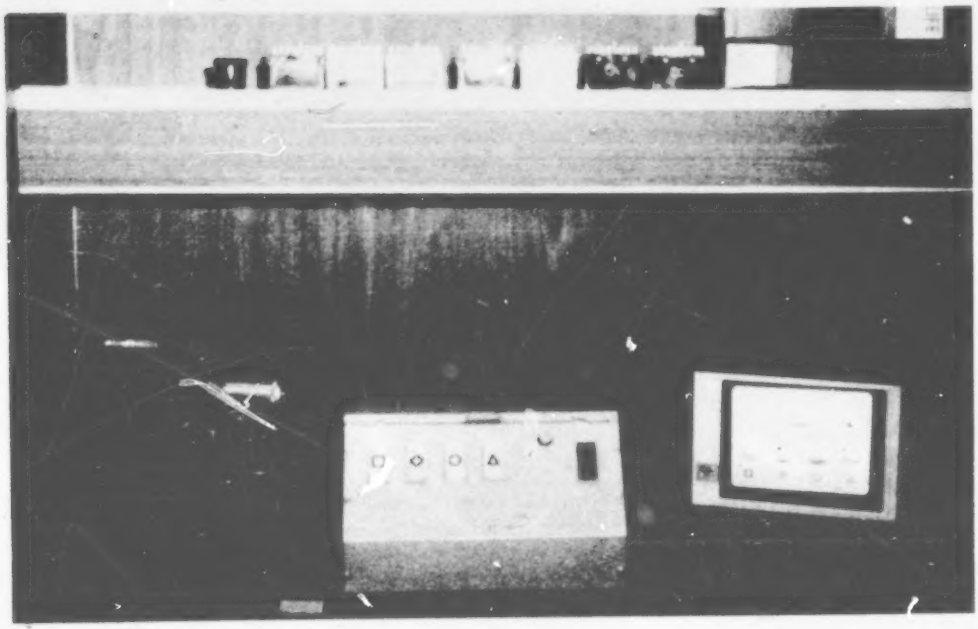


Exhibit 34. Project LIFE Device. American School for the Deaf, West Hartford, Connecticut.

Exhibit 35 shows two filmstrip frames from one of the more advanced programs. The symbols opposite the answers correspond to symbols on the console pushbuttons.

In reviewing the possibility of a film-based programmed learning vocational training system for the deaf, a number of similarities were noted in the learning and work behaviors of the hard of hearing and the retardate. Both types of learners appeared to be easily distracted and typically have limited attention span. Both appeared to need continuous repetition and reinforcement for learning, and to have limited ability to transfer learning from one situation to another. Both appeared to lack common social and work experiences associated with maintaining a job. On the other hand, both types of learners appeared to respond well to concrete learning experiences presented on a nonverbal level.

Based on the successful performance aid applications of learner-centered audiovisual instruction in industry; the encouraging results of industrial techniques used for vocational training of the mentally retarded; the positive findings of research dealing with programmed learning effectiveness for the deaf; and the early promise of Project LIFE, it seemed like the idea of the Electronic Assembly Self-Instructional Training System for the Deaf was a good one.

57

Ann and Joe have books.

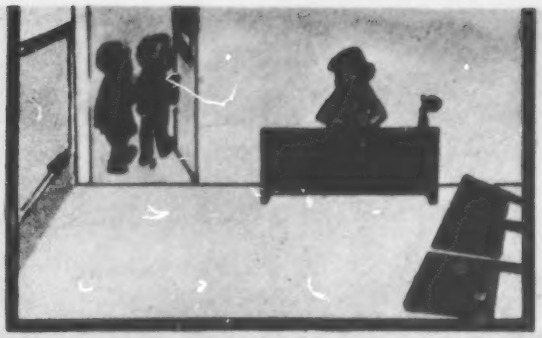
Ann's book is big.

_____ is little.

Her book ✣

His book ○

58



The teacher is in the schoolroom. □

Mary is in the schoolroom. ✣

Bob is in the schoolroom. ○

Exhibit 35. Filmstrip Frames: Project LIFE.

B. Chronology of Project Development

The proposal for development of the Electronic Assembly Self-Instructional Training System for the Deaf was formally submitted to Captioned Films for the Deaf, U.S. Office of Education, in September 1966. The proposed project development had two objectives:

1) First, to create a course of vocational training for deaf high school students which would prepare those students for jobs upon graduation.

2) And second, to base the training course on a model of instruction which could serve for the development and improvement of other curriculum, both vocational and academic.

The model proposed was that depicted in Exhibit 2.

Electronic assembly was chosen for course content only in part because of the history discussed in the foregoing pages. Prior to preparation of the proposal, a survey of employment opportunities had indicated electronic assembly to be an ideal job area for deaf high school graduates.

With growing emphasis by the military services on electronic systems, and with a growing consumer market for electronic products --- television, transistor radios, tape recorders, etc. --- an unending need for skilled assembly workers was foreseen. The job of the electronic assembler appeared to be well within the range of the deaf individual. Electronic assembly work requires manual and digital dexterity and the ability to interpret and carry out graphic instructions, but it does not necessarily demand listening or speaking skills. Furthermore, jobs in electronic assembly are open to both men and women.

Companies which had hired and trained their own deaf assemblers consistently reported that the deaf or hard of hearing individual typically did very well on the job. These companies included Hughes Aircraft Company, Culver City, California; the Boeing Company, Seattle Washington; Tektronix Corporation, Beaverton, Oregon; and TRW Systems, Redondo Beach, California.

Finally, not only does electronic assembly work pay well, but also an entry level job can be the first step on a career ladder. The job of electronic assembler has senior and specialist grades, and on-the-job and other company-provided training can open the door for advancement to jobs such as those of quality assurance inspector and electronic technician.

The project proposal outlined the following sequence of procedures for program development (Exhibit 36):

1) The first phase of the development effort would consist of an analysis of the electronic assembler's job to identify what specific skills, knowledge, and attitudes would have to be taught.

2) The results of the job analysis would serve as the basis for the construction of behaviorally defined learning objectives.[15]

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[15] Mager, Robert F. Preparing Instructional Objectives. Palo Alto, California: Fearon Publishers, 1962. 62 p.; Mager, Robert F. and Beach, Kennth M., Jr. Developing Vocational Instruction. Palo Alto, California: Fearon Publishers, 1967; Mager, Robert F. Developing Attitude Toward Learning. Palo Alto, California: Fearon Publishers, 1968.

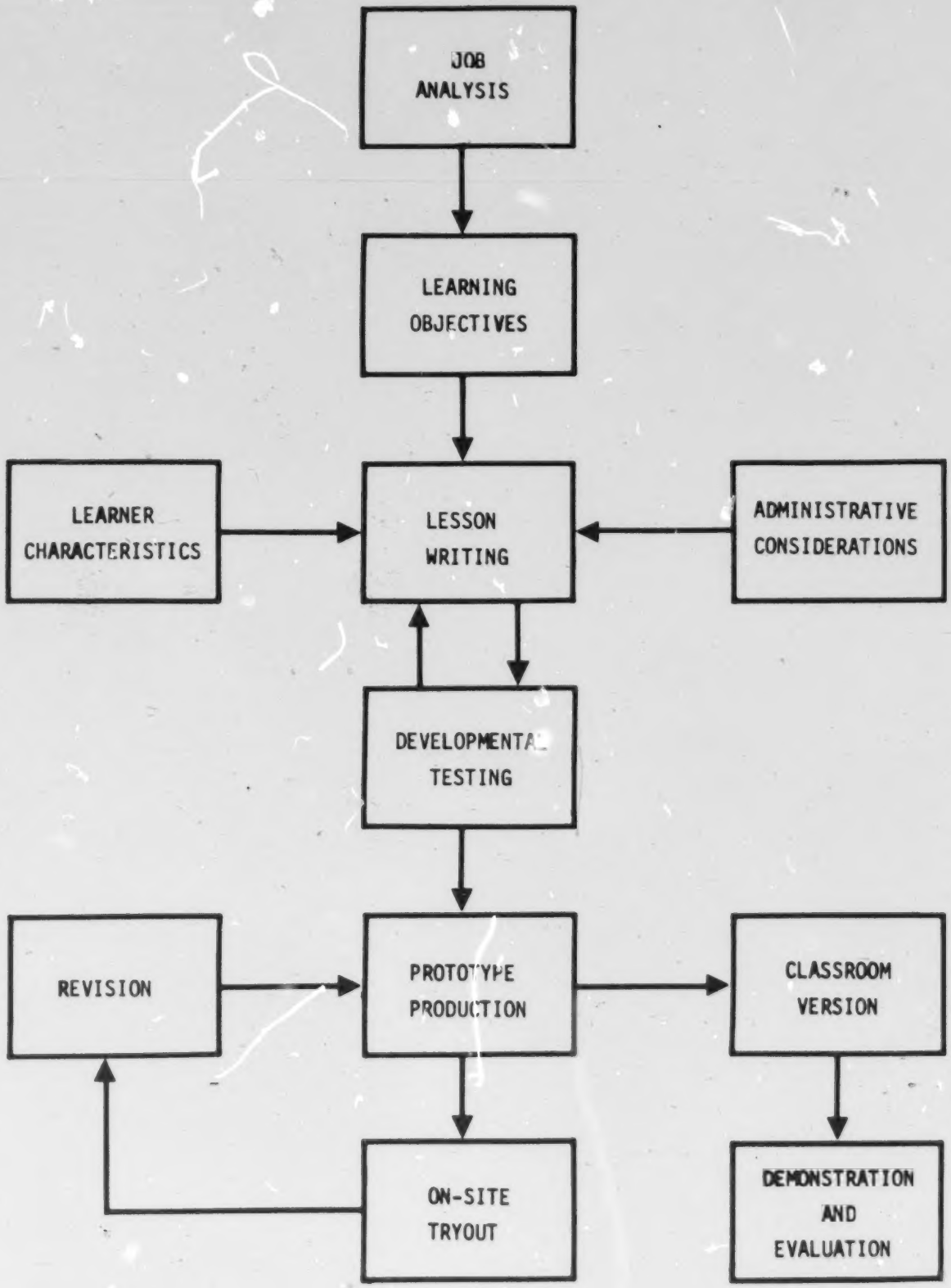

Exhibit 36. Procedural Model: Instructional System Development.

3) Lesson writing would begin with the organization of learning objectives into a course outline, followed by development of a lesson plan and the production of draft instructional materials. Lesson writing would take into account the special characteristics of the learner population and pertinent considerations related to school administration in education of the deaf.[16]

4) Developmental tryout would consist of limited but intensive testing of draft instructional materials with a limited sample of the learner population. The purpose of testing at this point is to expose basic deficiencies in the curriculum before lesson plans are finalized and expensive production work is begun. The number of tryout subjects might consist of no more than a single, well-chosen individual. The kind of data obtained is not intended to lend itself to statistical analysis, but is for the purpose of showing where revision and/or further refinement is necessary in lesson writing.

5) It was proposed that prototype film materials be produced as 35mm slides rather than filmstrips, in order to provide for maximum flexibility in on-site tryout administration and revisions following tryout.

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16 For a brief but more comprehensive discussion of this and other elements in the development process, see Persselin, Leo E. "Vocational Guidance Film Series: A Review and Analysis with Recommendations for Revision," report submitted to Media Services and Captioned Films, Bureau of Education for the Handicapped, U.S. Office of Education. TRW Systems, Redondo Beach, California, December 31, 1970.

6) On-site tryout would take place in representative schools for the deaf, with prototype program content administered by school personnel. Revision of the prototype materials would follow on-site tryout, with the cycle of tryout and revision continuing until instructional objectives were satisfactorily met.

7) Production of the classroom version of the system would consist of producing film materials in the form of filmstrip, and completing preparation of all other materials required for introducing the system into a school on an operational basis.

8) Classroom demonstration and evaluation of the system would follow introduction of the system into a number of representative schools.

Captioned Films for the Deaf accepted the proposal, and it was decided that the developmental effort should begin with the prototype production of three self-instructional programs only. Completion of the program series would be determined by results of the on-site tryout of the first three programs. The contract for production of the first three programs was given to Graphic Films Corporation, Hollywood, California, and work on the project began in May 1967.[17]

The initial phases of the development effort --- the job analysis and specification of learning objectives --- were conducted by Donald R. Robinson and J. Norman Swaton, two highly experienced instructional programmers with extensiye experience both in technical training and programmed learning.

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17 The initial proposal was prepared and submitted by the Project Director in his capacity of Director of Instructional Systems Development, Videosonic Systems Division, Hughes Aircraft Company, Fullerton, California. It was intended that Hughes be the contractor, but the company declined the opportunity because a corporate decision had been made to dissolve the Videosonic Systems Divison.

The job analysis included visits to both large and small electronics manufacturing plants in the Los Angeles area. In addition, relevant training materials were reviewed. These included NASA specifications and instructional materials; the Hughes slide/tape electronic assembly training series; and a self-instructional audiovisual program in soldering skills produced by General Programmed Teaching Corporation, Los Altos, California, for use at Jobs Corps Training Centers.

The job analysis resulted in learning objectives and outlines for three introductory programs: Use and Care of Small Tools, Mechanical Assembly, and Assembly Soldering. Technical consultant (subject-matter expert) during this and subsequent phases of development of the first three programs was Roger Taylor, quality assurance engineer, North American Aviation, Inc., Downey, California.

Program planning and initial lesson writing took place during a six-week production workshop conducted by Mr. Swaton and Mr. Robinson, and attended by Henry W. Zink, electronic assembly instructor, California School for the Deaf, Riverside; Harold Ramger, high school science instructor, California School for the Deaf, Berkeley; and John M. Fessant, supervising teacher of vocational education, Oregon School for the Deaf, Salem.

All of the teachers of the deaf were familiar with programmed learning, but none had extensive program writing experience prior to the workshop. By the same token, neither Swaton nor Robinson had previous experience in deaf education. During the workshop, which took place in July and August 1967, the three teachers of the deaf received intensive instruction in programmed learning techniques, while the two programmers learned about the characteristics of the deaf and the hard of hearing, and about problems in deaf education and school administration.

At the conclusion of the six-week workshop, draft versions of three instructional programs had been developed, and graphic art and photography had begun. Final program editing, graphic art, and photographic production were completed by Mr. Swaton, Mr. Robinson, and Graphic Films personnel.

During the fall semester 1967, tryout of the programs began at the California Schools for the Deaf, Riverside and Berkeley, and the Oregon School for the Deaf, Salem. One electronic assembly workbench was set up at each of these schools, installed in the classrooms of the teachers who had participated in the production workshop. These teachers now began administering the programs for tryout purposes.

By the spring of 1968, tryout results of the first three programs looked good enough so that a decision was made to complete the series. The contract for development of the remaining programs was given to TRW Systems Group, Redondo Beach, California.

Beginning in March and continuing through December 1968, draft versions of four instructional programs were developed: Wire Installation, Wire Harness Building and Installation, Component Installation, and Electronic Assembly Rework Techniques.

Again, program development began with in-plant job analyses, followed by specification of learning objectives and lesson writing. Under subcontract to TRW Systems, Mr. Robinson and Mr. Swaton conducted the job analyses, produced the draft versions of the instructional programs, and conducted developmental testing. Mr. Zink served as a consultant in developmental testing. Program content was reviewed and language and reading consultation was provided by Dr. William Blea, coordinator of language and reading programs for Los Angeles City Schools.

The developmental testing version of the programs consisted of black-and-white Polaroid prints mounted in a workbook. The Polaroid prints were mounted on the same page with the programmed text frames ultimately intended to accompany the color transparencies which the prints represented.

The Polaroid-print materials were administered to a single trainee --- a representative high school student from the California School for the Deaf, Riverside. The trainee went through the entire course of instruction while being closely monitored by the instructional programmers and consultants. The trainee was free to question the monitors at any time, and the monitors periodically interrogated the trainee.

In January 1969, after all four programs had undergone developmental testing and final editing, production of color transparencies was begun under the supervision of Ellen M. Howarth, senior assembly instructor, TRW Systems. During the spring of 1969, five sets of 35mm slides for each of the four programs were produced, together with accompanying programmed text and instructor's materials.

During summer school 1969, tryout of the prototype version of the four programs was conducted at the California School for the Deaf, Riverside. Four completely equipped electronic assembly workbenches were installed. Trainees who already had completed the first three programs in the series worked 90-minute periods daily. Those trainees starting with the introductory program, Use and Care of Small Tools, spent three hours a day at the workbench. The six-week tryout session was administered by Mr. Zink and Miss Howarth.

Exhibit 37 shows members of the project staff monitoring tryout activities at Riverside.

Exhibit 38 shows a newspaper clipping which describes the Riverside tryout.[18]

The remainder of 1969 was devoted to revision of the four programs which had undergone tryout during summer school. In addition, tryout data dealing with the first three programs were acquired and analysis begun.

During development of the last four programs in the series, tryout of the first three programs had continued not only at Riverside, but at the single-workbench installations in Berkeley and Salem. Site visits were made to all three of the schools to collect teachers' log books and all of the programmed textbooks in which trainees had entered written responses, and to interview both the trainees and the teachers --- Roy Pleyler, who had replaced John Fessant as the teacher in Salem; Eric Malzkuhn, who had replaced Harold Ramger at Berkeley; and Mr. Zink.

Tryout data from the first three programs were subjected to both item and statistical analysis, and revision of the programs began early in 1970. A major reorganization of program content resulted in the program titles and outlines as they now exist: Program 1 - Mechanical Assembly; Program 2 - Wire Preparation; and Program 3 - Assembly Soldering.

As in development of the last four programs, revised materials for the first three programs were subjected to testing in the Polaroid-print format before final color photography was begun. In this instance, however, devlopmental testing was conducted with junior high school students at the Southwest Los Angeles County School for the Deaf, Lawndale.

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18 "Program Accelerates Teaching the Deaf," Los Angeles Times, August 3, 1969. Section D, p 15.

Los Angeles Times Sun., Aug. 3, 1969—Sec. D 15

Program Accelerates Teaching the Deaf

BY URSULA VILS
Times Staff Writer

The teacher had the highest praise for a teaching system sometimes criticized as being "impersonal."

"This program," said Henry Zink, for 10 years a teacher at the California School for the Deaf, Riverside, "teaches as much in six weeks as I could in 36 weeks of conventional instruction."

He referred to a programed method of teaching electronic assembly that is being tested and refined at the school. Although used to train deaf teen-agers for jobs as electronic assemblers, the pilot project sought to develop a way to train other handicapped persons—including those hobbled by poverty and lack of education—for gainful employment in a growing industry.

Project Director

The Department of Health, Education and Welfare has funded the program and will make it available to train others throughout the nation. HEW also called on private industry to help make the program practical, not theoretical.

Dr. Leo E. Persselin of TRW's civil systems center is project director, with Ellen M. Howarth, who directs electronic training at TRW, as technical director. Dr. Persselin watched as four deaf teen-agers—two girls, two boys—worked and studied at their benches.

"Each student has a workbook that guides him step-by-step in actually assemblying an electronic circuit, "Dr. Persselin said. "Before him he has a tray of slides and projector, and he refers to these as instructed by the workbook.

Individual Attention

"The teacher—in this case, Henry Zink — is available to answer questions, give individual attention where necessary and to check the students' work."

The program includes seven steps ranging from learning the care and use of tools to electronic assembly rework techniques.

"We figure a student needs about 10 hours each on each of the seven steps," Dr. Persselin said.

"That means that in 70 hours he can qualify as an entry-level electronics assembler in industry.

"But each student proceeds at his own pace, and some have gone through in as little as 35 hours."

Zink, who has served as a consultant in developing the program, admitted he is amazed at its success. He explained some of the difficulties of teaching deaf students.

"We teachers have to be good actors as well as teachers," he said. "We limit our classes to 12 students and we fight to hold their attention for 15 minutes.

Reading Level

"But I've seen students stay with this electronic assembly training 180 minutes at a time. The basic principle of this type of instruction is that the student has to take certain action, has to perform a directed task such as soldering a wire.

"He must respond to the instruction, and this seems to keep him more interested."

Zink also said that the low reading levels of deaf students — a deaf high school graduate may read at sixth-grade level or less —makes any kind of instruction difficult.

"Some of these students," Dr. Persselin said, "read at only third or fourth-grade level. If this programed learning approach can succeed with them—and we feel it has —it opens all kinds of doors. It can be used for the educable mentally retarded, for ghetto residents with minimal education, for many others."

"One of the by-products of this program," Zink said, "is teaching language. I've noticed a big improvement in my students' language skills. They seem to absorb it as an automatic part of the program."

The students worked on despite the ending of the period, and Zink had to stop them. One of the most reluctant to leave was Geraldine Logan, a pretty girl with a warm, serene smile.

"Geraldine," said Zink, "was absolutely not interested in typing. But she is fascinated with electronics assembly. And she's a smart girl—she'll make a lot more money in electronics assembly."

Exhibit 38. Newspaper Clipping: "Program Accelerates Teaching the Deaf."

Through the cooperation of Dr. Harry Murphy, principal of the Southwest Los Angeles County School, an intensive two-week program of developmental testing was conducted, using seven 13- and 14-year-old girls and boys with reading achievement at the third- and fourth-grade levels. Only selected segments of the program materials were tested --- approximately one-third of the total content of the three programs. However, material from all three programs was included.

Under normal system administration, students as young as those in the Lawndale test group would never be accepted as trainees. The purpose of testing at this age level was to revise the reading level of the programs as far downward as possible. In achievement of this goal, important contributions were made by Dr. Blea in his continuing capacity of language and reading consultant.

New photography and text production for the first three programs began concurrent with the production of filmstrips and other materials for the classroom version. At the same time, plans were being made to introduce the system into a number of schools for demonstration and evaluation.

In the spring and early summer of 1970, four institutions were selected for this purpose: American School for the Deaf, West Hartford, Connecticut; California Schools for the Deaf, Riverside and Berkeley; and the Salem Rehabilitation Facility, Oregon. The reason for including the rehabilitation facility was to evaluate the system for instruction of other handicapped populations as well as the deaf.

With the beginning of school during the fall semester 1970, a total of 24 workbenches were installed at the four demonstration sites --- eight workbenches at American School for the Deaf, six workbenches at California School for the Deaf, Berkeley, five at the Salem Rehabilitation Facility, and a fifth workbench added to the four already at California School for the Deaf, Riverside.

At year's end, instruction was well underway at both of the California Schools for the Deaf, and was scheduled to begin early in 1971 at both American School for the Deaf and the Salem Rehabilitation Facility.

V. ANALYSIS AND EVALUATION

As noted in the foregoing pages, the classroom version of the Electronic Assembly Self-Instructional Training System was introduced into schools on an operational basis during the fall semester 1970. As of the date of this report, two schools had begun using the system: the California Schools for the Deaf, Riverside and Berkeley. Approximately 30 trainees had begun receiving instruction at the electronic assembly workbenches. None of these trainees, however, had advanced beyond the third program in the series.

Obviously, insufficient evidence exists to draw any conclusions from the demonstration and evaluation phase of the project at this date. However, during developmental testing and on-site tryout of prototype instructional materials, approximately 85 representative deaf and hard of hearing boys and girls completed all or at least part of the series of seven self-instructional programs. While conclusions drawn from their experience are necessarily tentative and incomplete, substantial data do exist which provide clear indications of system effectiveness.

The discussion which follows is based on performance data accumulated during the developmental testing and on-site tryout of prototype materials, and during the fall semester 1970 at the California Schools for the Deaf, Riverside and Berkeley.

A. Instructional Effectiveness

All evidence indicates that if properly administered, the instructional system will result in achievement of the specified learning objectives by deaf high school students of at least normal intelligence and a 3.5 grade level in reading.

Other instructional benefits are also indicated. Substantial improvements in reading ability, language skills, and study habits were noted on the part of those trainees who completed the instructional programs.

Because improvement of reading and language skills was not one of the specific objectives of the project, no statistical data were accumulated to show this improvement. However, trainees with median or low reading abilities, and with no previous exposure to technical terminology very rapidly began adding words to their vocabulary like the following: anti-wicking tweezer, bifurcated terminal, grommet, glyptal, soldering, swaging, torque, ratchet, thermal, diagonal, insulation, seizer, fillet, turret, stress, crimp, harness, circuitry, component, syringe, replacement. The trainees used the words correctly, and they spelled the words correctly.

Of necessity, in the course of completing the instructional programs, the trainees learned to read instructions carefully, to interpret those instructions, and to follow them exactly. This was a difficult achievement for many of the students who came to the training course with poor reading and study habits.

A related problem for many trainees was that of learning independently. Deaf students tend to be highly dependent on their teachers. In beginning their programs of self-instruction, most trainees felt very uncomfortable in being asked to proceed on their own. The final outcome for many trainees included a substantial improvement in self-confidence.

As discussed on pages 53-56 (Length of Curriculum) and indicated in Exhibit 28, the data show that trainees who had the highest examination scores and produced the best workmanship also tended to proceed through the course of self-instruction at the fastest pace. A prime variable in the pace of self-instruction was that of the individual period of instruction. The longer the daily period of instruction, the faster the pace tended to be.

B. Adaptiveness to Individual Differences

Administration of instruction both during tryout and regular school operations revealed the system to be both flexible and adaptive to trainees' individual styles of responding to programmed textbook and filmstrip materials.

The self-instructional program materials were designed for a trainee to begin with a frame of text instruction and its coordinated frame of filmstrip, and then proceed frame-by-frame through text and filmstrip simultaneously for the duration of each instructional period. Some of the trainees proceeded in exactly this manner. Others, however, would first review the upcoming section of text material only, return to the beginning of the section, and then proceed frame-by-frame through both text and filmstrip. Others would begin each instructional period by first reviewing upcoming filmstrip material independently, and then return to receive instruction frame-by-frame from both text and filmstrip.

The last pattern --- reviewing the filmstrip independently before beginning frame-by-frame, coordinated text and filmstrip instruction --- appeared to be the most prevalent. Trainees were permitted to proceed in whatever way was most comfortable for them. No differences in learning achievement were noted as the result of these different approaches to self-instruction.

Another aspect of individual differences in trainee behavior was manifested in the intersocial relationships between trainees at adjacent workbenches.

Some trainees tended to ignore one another completely. Others would monitor their neighbors' work, compare workmanship, and sometimes discuss the instruction. Pairs of trainees at adjacent workbenches would sometimes pace each other, not trying to outdo one another, but carefully keeping abreast of one another as they proceeded through their programs. Others would compete, attempting to work as rapidly as possible in order to keep up with faster individuals.

Trainees appeared to benefit from comparing their work and pacing one another. However, the highly competitive individual typically tended to work faster than was good for him. He would tend to skip instruction or not respond correctly, and his workmanship would suffer. The teacher constantly would have to prescribe remedial instruction and try to slow him down in order to bring his work up to standard.

C. Peer-Tutor Characteristics

Administration of the system in a multiple-workbench situation appeared to stimulate highly productive peer-tutor relationships among trainees. Without being initiated by the teacher, these relationships developed spontaneously in every group (Exhibit 39).

Slower learners needing help would turn to those who were proceeding faster and doing better. The faster trainee appeared to enjoy the role of tutor, and typically did an effective job.

Once begun, constructive peer-tutor relationships were strongly encouraged. They proved not only to be mutually beneficial to the trainees, but also were very helpful to the teacher. Peer-tutor relationships tended to relieve demands on the teacher's time during critical periods of introducing new trainees into the system, administering and grading examinations, etc.

D. Motivational Aspects

As noted in pages 56-58 (Trainee Entry Requirements), a student's behavior in the training system often was quite different from his behavior in other types of instructional situations. Trainees with limited attention span in the conventional classroom typically would spend hours absorbed in their work at the electronic assembly workbench.

The system tended to be highly motivating for those trainees who entered instruction wanting to learn electronic assembly skills, and it tended to maintain and strengthen the interest of those who at least were willing to find out what the course was all about.

There were no indications of Hawthorne effect --- interest in the course did not diminish as the novelty of the system wore off. To the contrary, interest increased as the trainee moved from program to program, advancing to increasingly more complex aspects of the electronic assembler's job, learning to use new tools, perfecting the skills he was learning, gaining increased confidence in his ability to follow technical instructions and do exactly what was required, and having the satisfaction of actually building something.

No attempt was made to introduce motivational stimuli into textbook or filmstrip content. The chassis assembled by each trainee were non-functional. Nothing built by the trainee could be plugged in and made to work. This did not seem to make any difference.

During the Riverside summer school tryout in 1969 (see pages 83-85), the trainees were taken on a field trip to tour the manufacturing facilities of TRW Systems Group, Redondo Beach, California. The visit was made at a time when most of the trainees had progressed more than half-way through the series of seven programs. One of the tour guides was a deaf electronic assembler with several years of on-the-job experience at TRW Systems.

Trainees had the opportunity to see skills they were learning actually being applied in real-life work situations. They watched while assemblers put together components for spacecraft and communication satellites --- in many instances working with types of assembly instructions and wire harness boards almost identical to those in the training system.

The experience was highly stimulating. A comparable field trip would be recommended for every trainee who goes through the system.

E. System Administration

A very comprehensive determinant of instructional effectiveness is that of system management and administration. The trainee always must be able to find tools, parts, and materials exactly where they are supposed to be on the workbench at the moment he needs them. Making sure that everything is where it is supposed to be is an important part of the teacher's job. In addition, the teacher always must be available when a trainee needs him. No matter how few self-instructional workbenches are occupied, administration of the system is a full-time job.

As discussed on pages 58-59 (Teacher Requirements), the most important qualification for the teacher is a knowledge of electronic assembly techniques and standards. Experience in initiating instruction at the California Schools for the Deaf, Riverside and Berkeley, during the fall semester 1970, has borne this out.

None of the teachers at the four demonstration and evaluation sites had previous experience in deaf education or in communicating with the deaf. All of them had experience in electronics, however.

At American School for the Deaf, West Hartford, Connecticut, the system was introduced into the curriculum by Edmond Cassetti, Director of Vocational Education and Rehabilitation Services (Exhibit 40). To teach the course, Mr. Cassetti, who himself has experience in electronics, selected Paul Rakyta, who came to the school directly from 25 years in the electronics industry.

The teacher at the Salem Rehabilitation Facility, Oregon, is Mrs. Josephine Copple (Exhibit 40). Mrs. Copple previously had instructed and supervised wire harness building and other electronic assembly subcontract work at the Facility's sheltered workshop.

Gerald Peterson (Exhibit 41), the teacher at the California School for the Deaf, Riverside, is a recent college graduate in education with electronic experience both in the Navy and in industry.

Sam Nolan (Exhibit 41), the teacher at the California School for the Deaf, Berkeley, is a 25-year retired veteran of Naval electronics who came to the school directly from a job as an electronic technician in a government research laboratory.

To date, no major problems in system administration have emerged at the demonstration and evaluation schools. The minor difficulties encountered have been typical of what might be expected during the start-up of any innovative course by a teacher with no previous experience in deaf education. At both Riverside and Berkeley, the trainees' pace of advancement and the quality of their work have been consistent with that was produced during the tryouts administered by project personnel and consultants.

F. Application of the Instructional Concept

Experience to date indicates that the instructional model upon which the system is based (see pages 6-8, Instructional Concept) is a valid one for this particular instructional application. The combination of programmed textbook and filmstrip materials has more than fulfilled expectations.

As recently as the summer of 1969, consultants in deaf education and electronic assembly were continuing to estimate that it would not be possible to successfully administer the system to an individual with a reading level of lower than sixth grade. The achievement in lowering that grade level to 3.5 is a direct result of the careful planning and construction of lesson content and the developmental testing, prototype tryout, and revision procedures which were followed in program development.

The concept which underlies the combining of programmed textbook and filmstrip materials in the system is one of complementary communication. Lesson presentation does not consist of text material illustrated by the filmstrip. Neither does it consist of a filmstrip presentation supplemented by text.

The specific objective of each step of lesson presentation was analyzed to determine how each of the media could be used in its own best manner to the fullest effect for communicating instructional content. Text and filmstrip materials were then developed concurrently. The aim was to make programmed textbook and filmstrip content as complementary and mutually reinforcing as possible, while at the same time avoiding redundancy and keeping the communication as simple and as unambiguous as possible.

The success of the instructional concept and the programmed textbook/filmstrip approach for deaf high school students has suggested that they might be just as valid not only for other handicapped populations, but also for individuals with a broad range of learning problems. The administration of the instructional system at the Salem Rehabilitation Facility will test this possibility during the coming year.

It has been suggested also that the instructional system might prove effective for learners with English as a second language, e.g., Spanish-speaking populations. The supposition is that the system not only would succeed in teaching such learners vocational skills, but also might substantially improve their English language skills. This remains to be determined.

What is most evident at present is that the instructional concept and the media approach used in the electronic assembly system might be highly adaptable to the programmed learning of other vocational subjects. Suggestions have included vocational areas of printing, automotive work, and electronic theory, and advanced areas of electronic assembly, quality assurance, and the work of the electronic technician.

In the Electronic Assembly Self-Instructional Training System for the Deaf, the concept works. It lends itself to practical application in an operational school situation. It results in learning. The learners appear to enjoy the experience.

The Project Director visited the California School for the Deaf, Berkeley, during the first week of system administration during the fall semester 1970. As he was leaving the electronic assembly classroom at the end of the second day, one of the trainees handed him a note. The trainee was a young girl who was having an extremely difficult time, and who was advancing more slowly than the rest of her group. The note is Exhibit 42.

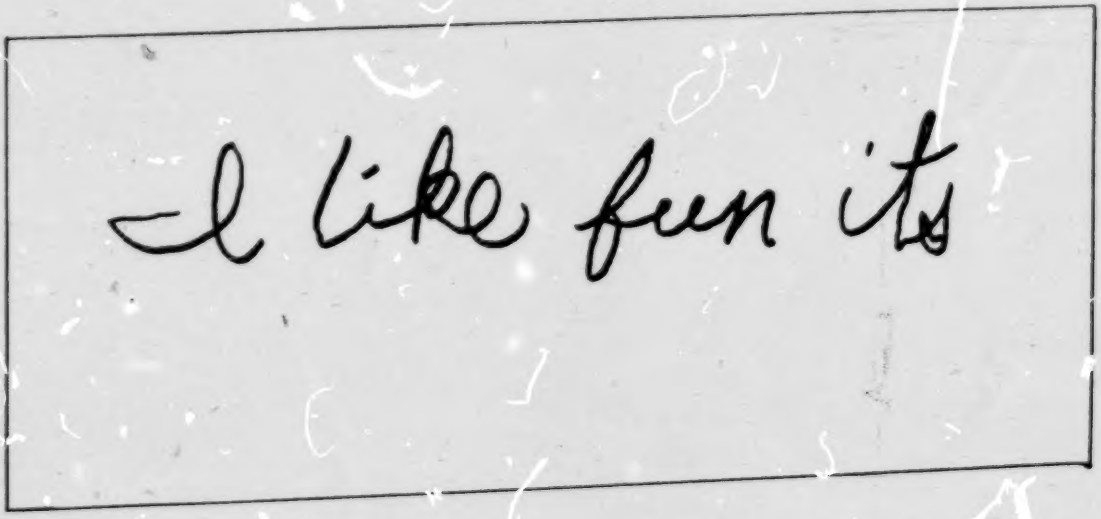

Exhibit 42. Note From Trainee.